PB-215 852

TRAINING MANUAL. SWIMMING POOLS. DISEASE CONTROL THROUGH PROPER DESIGN AND OPERATION

Jerrold M. Michael

Communicable Disease Center
Atlanta, Georgia

1959

DISTRIBUTED BY:

NTIS
National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

PB 215 852

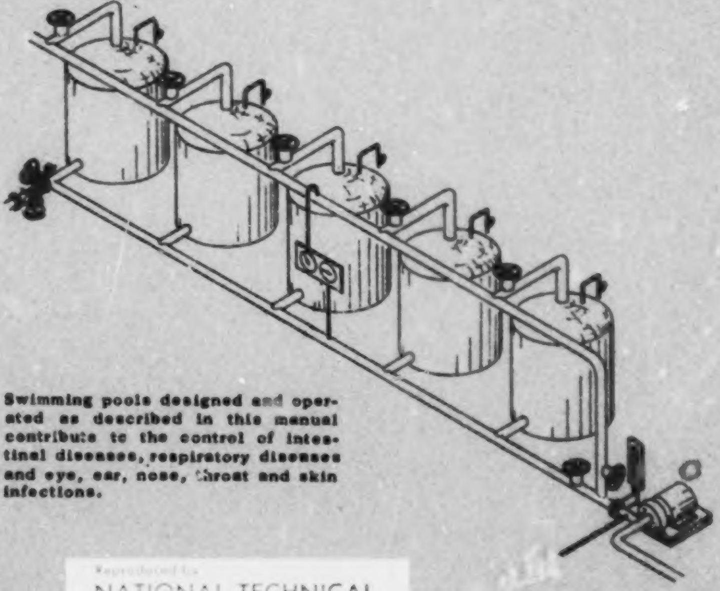
CDC

TRAINING MANUAL

✱ENVIRONMENTAL SANITATION SERIES✱

SWIMMING POOLS

DISEASE CONTROL THROUGH PROPER DESIGN AND OPERATION



Swimming pools designed and operated as described in this manual contribute to the control of intestinal diseases, respiratory diseases and eye, ear, nose, throat and skin infections.

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U S Department of Commerce
Springfield VA 22151

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service

152

Training Manual

SWIMMING POOLS

Disease Control Through Proper Design and Operation

Lecture Outlines
and Reference Material

Jerrold M. Michael
Sanitary Engineer
Training Consultant

Details of illustrations in
this document may be better
studied on microfiche.

Department of Health, Education, and Welfare
Public Health Service
Communicable Disease Center
Training Branch
Environmental Health Training Section

1959

Public Health Service Publication No. 665

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON :

FOREWORD

Since man normally does not live in an aquatic environment, he is at potential risk each time he consumes or has bodily contact with water. Diseases such as typhoid and paratyphoid fever, amoebic dysentery, leptospirosis, and bacillary dysentery, sometimes associated with contaminated drinking water, can be spread also through contact with the contaminated water of swimming pools. In addition, the swimming pool and surrounding areas frequently play a role in the transmission of infections of the eye, ear, nose, and throat, and in the spread of athletes foot, impetigo, and other dermatoses. In light of these considerations, the proper construction, operation, and maintenance of public swimming pools is a public health problem of growing magnitude, particularly since the pool building industry has experienced a phenomenal growth during the past decade.

The first edition of this training manual, authored by Jerrold Michael, Sanitary Engineer, was issued as a mimeographed series of outlines in early 1954. The demand for this material prompted the publication's revision in late 1954 and 1955. One year later a printed brochure titled "Course Outline - Swimming Pools" was prepared for use by health jurisdictions in training programs designed specifically for public health workers and swimming pool operators.

This current edition represents the latest information on design, construction, operation, maintenance, and the effect of each on disease control practices. It is organized specifically to serve as a training and reference guide for State and local public health personnel, and especially for further use in the conduct of their own in-service training programs. In addition, we hope that this volume will serve a useful purpose in the development of training programs from which operators and owners of swimming pools may be expected to benefit.

Donald S. Martin

Donald S. Martin, M.D.
Chief, Training Branch

TABLE OF CONTENTS

Subject .... Page

A. Suggested Short Course Outline 1

B. Lecture Outline - Introduction to Swimming Pool Sanitation 5
  1. Swimming Pools and Health 5
  2. The Role of the Health Department 6
  3. Types of Swimming Places 11
  4. Basic Principles for Healthful Swimming 12

C. Lecture Outline - Constructing and Remodeling a Public Swimming Pool and Bathhouse 15
  1. Basic Considerations 15
  2. Designing Pool Size to Fit the Expected Swimming Load 22
  3. Sanitary Construction Requirements 23

D. Sample Calculations for Maximum Swimmer Load 59

E. Illustrative Problem - Calculations, Review of Swimming Pool Plans 61

F. Check List - Sanitary and Public Health Items Relating to Swimming Pools 71

G. Lecture Outline - Operation and Maintenance of a Public Swimming Pool and Bathhouse 81
  1. Patron Load Control 81
  2. The Maintenance of the Proper Disinfectant and pH Level in Pool Water 83
  3. Operation and Maintenance of Pool Recirculatory and Disinfection Equipment 86
  4. Algae Control 101
  5. Pool and Pool Area Maintenance 103
  6. Off-Season Protection 105
  7. Service Operations and Maintenance 106

H. Lecture Outline - Testing Swimming Pool Water for Chlorine Residual and pH 117

I. Lecture Outline - Inspection of Pool Installation and Bacteriological Sampling of Public Swimming Pool Waters 123
  1. Swimming Pool Inspections 123
  2. Bacteriological Sampling of Pool Waters 129
  3. Bacteriological Analysis of Pool Waters 130

J. Operation Check List for Swimming Pools 139

K. Index 143

Preceding page blank

LIST OF ILLUSTRATIONS

Figure	Title	Page
1.	Typical Plan of Pool Service Facilities	16
2.	Longitudinal Section Through Pool Showing Fittings	17
3.	Swimming Pool Piping System	19
4.	Swimming Pool Equipment Room	22
5.	The Diatomite Filter	37
6.	Basic Principles Involved in Chlorine Feeder Design	42
7.	Evolution of Chlorine Feeder Design as Improvements were Added	42
8.	Diagram Illustrating the Relationship of Chlorine Gas Feeder Components	42
9.	Flow Diagram - Chlorinator	44
10.	Plan View of Swimmer Load Problem Pool	59
11.	Isometric View of Design Problem Pool	61

LIST OF TABLES

Table	Title	Page
I.	Swimming Pool Water Treatment Diagram	68
II.	Filtration Area of Vertical Pressure Sand Filters	69
III.	Filtration Area of Horizontal Pressure Sand Filters	70
IV.	Quantities of Hypochlorite Needed for Preparing 10 Gallons of 10% Solution (10,000 ppm)	88

LIST OF SUGGESTED FORMS

Title	Page
Swimming Pool Construction Request	8
Check List of Sanitary and Public Health Items Relating to Swimming Pools	71
Swimming Pool Sanitary and Safety Requirements	110
Pool Operator's Weekly Report	111
Swimming Pool Inspection Report (Field Record)	125
Swimming Pool Inspection Report (Office Record)	127
Liquids Sampling Report	128

Suggested Short Course Outline

The outline detailed below is suggested for presentation primarily to public health workers concerned with the broad field of swimming pool sanitation. Adaptions of the basic outline can be made in order to present information more nearly suited to groups with specialized interests such as, public health workers concerned with pool plan review or swimming pool operators and managers.

SWIMMING POOLS - DISEASE CONTROL THROUGH PROPER DESIGN AND OPERATION

FIRST DAY

8:00 - 8:20	Registration and Introduction - Proposed subject matter and course layout
8:20 - 9:20	Section I - Introduction to Swimming Pool Sanitation 1. Diseases of Concern 2. The Role of the Health Department 3. Types of Swimming Places 4. Basic Principles of Healthful Swimming
9:20 - 9:35	Break
9:35 - 10:45	Section II - Constructing and Remodeling a Public Swimming Pool and Bathhouse 1. Basic Considerations of Recirculatory Pools 2. Designing Pool Size to Fit the Expected Swimming Load - Sample Calculations
10:45 - 11:00	Break
11:00 - 12:00	3. Sanitary Construction Requirements a. Pool Water Supply b. Pool and Pool Area c. Pool Shape, Design and Floor Slopes d. Pool Deck Area e. Outlets f. Return Water Inlets g. Lighting h. Hose Connections i. Overflow Gutters j. Surface Skimmers k. Steps and Ladders l. Pool Location and Surroundings

	m. Diving Boards and Floats
	n. Spray (wading) Pools
	o. Life Guard Stands
12:00 - 1:00	Lunch
1:00 - 2:00	p. Recirculation System and Appurtenances (1) Pumps (2) Filters (3) Chemical Feeders (4) Auxillary Equipment
2:00 - 2:15	Break
2:15 - 3:00	q. Disinfection Equipment (1) Gas Feeders (2) Other Feeding Devices r. Water Temperature Control
3:00 - 4:30	Field Visit - Recirculatory Pool - Pressure Sand Filter
4:30 - 5:00	Critique of Field Visit

SECOND DAY

8:00 - 9:00	Section II - Constructing and Remodeling a Public Swimming Pool and Bathhouse (Continued) 3. (Continued) Sanitary Construction Requirements s. Equipment Room t. Swimmer Preparation Facilities (1) Dressing Rooms (2) Clothing Storage (3) Sanitary Facilities u. Food Service Facilities
9:00 - 9:15	Break
9:15 - 11:15	Section III - Review of Swimming Pool Plans - Lecture and Class Exercise

11:15 - 12:00	Section IV - Operation and Maintenance of a Public Swimming Pool and Bathhouse 1. Patron Load Control 2. Conduct of the Tests for Disinfectant Residual and pH Level
12:00 - 1:00	Lunch
1:00 - 2:00	3. The Maintenance of the Proper Disinfectant Residual and pH Level 4. Hair Strainer Maintenance 5. Make-Up Tank Operation 6. Pumps and Motors
2:00 - 2:15	Break
2:15 - 3:00	7. Disinfection Equipment a. Chlorinator b. Hypochlorinators
3:00 - 4:30	Field Visit - Recirculatory Pool - Diatomaceous Earth Filter
4:30 - 5:00	Critique of Field Visit

THIRD DAY

8:00 - 9:00	Section IV (Continued) - Operation and Maintenance of a Public Swimming Pool and Bathhouse 8. Chemical Feeding Equipment a. Coagulant Feeders b. pH Control Feeders c. Filter Aid Feeders
9:00 - 9:15	Break
9:15 - 10:15	9. Filtration Equipment a. Pressure Sand Filters b. Diatomaceous Earth Filters
10:15 - 10:30	Break

10:30 - 12:00	10. Algae Control 11. Pool and Pool Area Maintenance 12. Off-Season Protection 13. Service Operations and Maintenance
12:00 - 1:00	Lunch
1:00 - 2:00	14. Athletes' Foot Control 15. Suit Handling and Disinfection 16. Swimmer Inspection and Personal Regulations 17. Safety 18. Operational Records
2:00 - 2:15	Break
2:15 - 3:45	Section V - Inspection of Pool Installations and Bacteriological Sampling of Public Swimming Pool Waters 1. Inspection Policies and Techniques 2. Sampling 3. Sample Analysis 4. Sample Interpretation
3:45 - 4:00	Break
4:00 - 4:15	Section VI - Operation Check List for Swimming Pools
4:15 - 5:00	Section VII - Quiz

Lecture Outline

INTRODUCTION TO SWIMMING POOL SANITATION

I. SWIMMING POOLS AND HEALTH

A. GENERAL - Current epidemiologic evidence indicates that well constructed and operated swimming pools and other public bathing places are not a major public health problem, but potentially, since man is not an aquatic animal, they could become one. No one can deny the public health impact of swimming in what in some cases could be classed as "dilute sewage."

B. DISEASES OF CONCERN

1. Intestinal Diseases - Typhoid fever, paratyphoid fever, amoebic dysentery, leptospirosis, and bacillary dysentery can be spread from one swimmer to another or become a problem where swimming waters are polluted by domestic or animal sewage or wastes.

   Leptospirosis may be pointed out as just one disease that has been implicated in swimming pool outbreaks in Wyoming, Idaho, and Georgia.

2. Respiratory Diseases - Colds, sinusitis, and septic sore throat might be spread more readily in swimming areas due to close contact, coupled with lowered resistance due to exertion.

3. Eye, Ear, Nose, Throat and Skin Infections - The washing away of protective mucous discharges, the washing of harmful organisms into ear and nasal passages, and the excessive use of water treatment chemicals in addition to the presence of harmful infections in the water, contribute to eye, ear, nose, throat and skin infections. Close physical contact and the presence of fomites also have their places in the spread of athlete's foot, impetigo, and dermatitis.

C. ACCIDENTS - By far, the greatest problem in control of swimming pools is the appalling number of accidents and drowning deaths. Lack of bather supervision is a prime cause, as is the improper construction, use, and faulty maintenance of equipment. Some particular problem areas are:

1. Diving Board Loose
2. Water Slides Badly Located
3. Projecting or Ungrated Pipes
4. Electrical Equipment Improperly Installed or Maintained
5. Chlorinators Improperly Vented
6. Permitting Glass Bottles to be Used in the Pool Area

II. THE ROLE OF THE HEALTH DEPARTMENT

A. It Cooperates With Local Governing Bodies Toward the Adoption of a Sound Swimming Pool Construction and Operation Ordinance.

B. It Serves in a Consultant Capacity to Swimming Pool Contractors, Architects, and Engineers Concerned With This Problem.

C. It Reviews Plans and Specifications for New and Remodeled Pools. (See, Illustrative Problem - "Calculations - Review of Swimming Pool Plans," page 61.)

1. Importance of Pre-Construction Plan Review
    a. Avoidance of code violations
        (1) Review can save the builder time and money.
        (2) Review can save the sanitarian from the unpleasant task of requiring changes.
    b. Building in of details which are not part of the health code.
        (1) Details from other pools might be suggested to the builder and prospective owner.
        (2) Suggestions regarding building and zoning department responsibilities can be offered to the builder.

c. Developing the owner-health department relationship on a sound basis from the start.

(1) This first contact can build a "consultant" relationship.

(2) By working with the owner, an opportunity is afforded to discuss health department operation requirements and procedures.

2. How can the Health Department Obtain Plans and Specifications? (See suggested application form for review of swimming pool plans entitled, "Swimming Pool Construction Request," page 8.)

a. Plans brought in by the pool contractor

(1) Many contractors and prospective owners are aware of the local regulations from a previous contact.

(2) Some contractors have had previous experience with health departments in other areas.

b. May be referred by a different health department

(1) Contractors may be referred from a local department to the State health department.

(2) Contractors may be referred from a State health department to a local department.

c. May be referred by another city, county, or State department as a routine system

(1) Some building departments will not issue a building permit for a swimming pool until a health department check is made.

(2) Fire, police, parks, and zoning departments may refer construction plans.

d. Construction or remodeling is noted by a health department representative on his normal rounds

The following form is presented as a model form to be used in accepting swimming pool plans for review.

SHEET No. 1

FOR ____________________ **HEALTH DEPARTMENT**

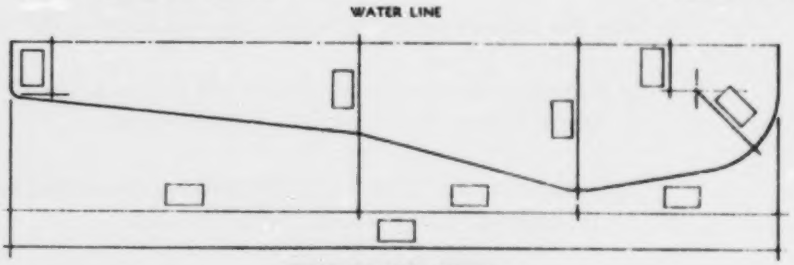
SWIMMING POOL CONSTRUCTION REQUEST

GENERAL INFORMATION:

ARCHITECT ☐ DATE ____________
BUILDER ☐
REQUEST FOR ____________________ OWNER ☐ PHONE ____________
ADDRESS ____________________ CITY ____________ COUNTY ____________
PUBLIC ☐
POOL FOR ____________________ SEMI PUBLIC ☐ PHONE ____________
PRIVATE ☐
JOB LOCATION ____________________ CITY ____________ COUNTY ____________
LEGAL DESCRIPTION ____________________ LOT NO. ____________ BLOCK NO. ____________
SEALED BIDS YES ☐ NO ☐ OPENING DATE ____________ TIME ____________ DELIVER TO ____________
BID OPENING AT ____________________
POOL CONTRACTOR ____________________ LICENSE NO. ____________
ADDRESS ____________________ CITY ____________ PHONE ____________
SPECIAL NOTES: ____________________

GENERAL POOL INFORMATION:

MAIN POOL		WADING POOL	
____________ SHAPE	AVERAGE LENGTH FT. ________	____________ SHAPE	AVERAGE LENGTH FT. ________
____________ SIZE	AVERAGE WIDTH FT. ________	____________ SIZE	AVERAGE WIDTH FT. ________
	AVERAGE DEPTH FT. ________		AVERAGE DEPTH FT. ________
	PERIMETER WATER LINE FT. ________		PERIMETER WATER LINE FT. ________
	WATER AREA SQ. FT. ________		WATER AREA SQ. FT. ________
	APPROXIMATE GALLONS ________		APPROXIMATE GALLONS ________



SHAPE OF POOL BOTTOM

GENERAL CONSTRUCTION INFORMATION:

POOL STRUCTURE— GUNITE ☐ POURED CONCRETE ☐ CEMENT BLOCK ☐ FIBER GLASS ☐ PLASTIC ☐
OTHER ____________________

SCUM GUTTER	YES ☐	NO ☐	**SKIMMER SLOT**	YES ☐	NO ☐
RECIRCULATING TYPE	YES ☐	NO ☐	RECIRCULATING TYPE	YES ☐	NO ☐
BALANCE TANK	YES ☐	NO ☐	BALANCE TANK	YES ☐	NO ☐
FULL TILE	YES ☐	NO ☐	FULL TILE	YES ☐	NO ☐
RECESSED OR OPEN ________			NUMBER INCLUDED ________		
LENGTH IN FEET ________			LENGTH IN INCHES ________		

HEALTH DEPARTMENT APPROVAL
BY ____________________
DATE ____________ TIME ____________

TRIM AND FINISH
POOL WALLS & BOTTOM ____________________
TILE ____________ SIZE ____________ COLOR NO. ____________
COPING ____________________ COLOR NO. ____________
RACE LANES: QUANTITY ____________ TILE ☐ PAINT ☐ COLOR ____________

DECKING
TYPE ____________________
FINISH ____________________
TOTAL AREA SQ. FT. ____________

SPECIAL NOTES: ____________________

Reprinted with permission of the Arizona State Health Department

SHEET No. 2

MISCELLANEOUS:

SITE PREPARATION____

EXCAVATION. REMOVE YES ☐ NO ☐ SOIL TYPE____ ACCESSIBILITY____

POOL AND DECK ELEVATION: ABOVE GRADE IN.____ BELOW GRADE IN.____ POOL IN FILL IN.____

PUMP AND EQUIPMENT LOCATION, FROM MAIN DRAIN IN FEET____ EQUIPMENT INSTALLATION____ GROUND

POOL CONTRACTOR TO FURNISH: EQUIPMENT ROOM ☐ EQUIPMENT PIT ☐ EQUIPMENT SLAB ☐ NONE ☐

POOL EQUIPMENT—FROM UTILITIES: GAS____FT. WATER____FT. POWER____FT. DRAINAGE____FT.

UTILITIES BY OWNER ☐ BY POOL CONTRACTOR ☐ OTHER____

MECHANICAL INFORMATION:

FILTER PLANT. MAKE____ CATALOG NO.____

PRESSURE SAND AND GRAVEL FILTERS	**DIATOMACEOUS EARTH FILTERS**
QUANTITY____DIA. IN.____SIDE SHEET IN.____	FILTER ELEMENTS CLOTH ☐ METAL ☐ STONE ☐
CODE TANKS YES ☐ NO ☐ TEST PRESSURE____	PRESSURE TYPE ☐ GRAVITY ☐ VACUUM ☐
TOTAL FILTER AREA OF PLANT SQ. FT. ____	TOTAL AREA OF FILTER PLANT SQ. FT. ____
CIRCULATION RATE GALLONS PER MINUTE ____	CIRCULATION RATE GALLONS PER MINUTE ____
BACKWASH RATE GALLONS PER MINUTE ____	BACKWASH RATE GALLONS PER MINUTE ____
TURN OVER RATE IN HOURS AND MINUTES ____	TURN OVER RATE IN HOURS ____

FILTER ACCESSORIES

UNDERDRAINS: DISH TYPE ☐ PLASTIC ☐ STEEL ☐ BRASS ☐ OTHER____

AIR RELIEF AUTOMATIC VALVE ☐ CONTINUOUS WITH VALVE AND PIPING ☐ HAND OPERATED ☐ NONE ☐

PRESSURE GAUGES QUANTITY____SIZE____ GAUGE BLOCK ☐ VENTURI ☐ TIME CLOCK SINGLE POLE ☐ DOUBLE POLE ☐

FOURWAY CONTROL VALVE____SIZE____CATALOG NO.____

CIRCULATING PUMP____ STYLE NO.____

SIZE____x____ ____HP.____PH.____CY.____VOLTS____R.P.M. SELF PRIMING YES ☐ NO ☐

CIRCULATING RATE____G.P.M.____T.D.H. BACKWASH RATE____G.P.M.____T.D.H. STRAINER SIZE____

RECIRCULATING SKIMMERS____ CATALOG NO.____

CAST IRON ☐ GALVANIZED IRON ☐ BUILT IN AUTOMATIC LEVEL ☐ BALANCE LINE AND VALVE ☐

BUILT IN OVERFLOW ☐ REMOVABLE STRAINER BASKET ☐ OTHER____

CHLORINATOR____ CATALOG NO.____

GAS TYPE ☐ ELECTRIC HYPO ☐ WATER OPERATED ☐ FLOAT ☐ CAPACITY____

CHEMICAL FEEDERS____CAPACITY LBS.____QUANTITY____

HEATER____ CATALOG NO.____

B.T.U. IMPUT____ AQUASTAT ☐ WIRING ☐ STACK VENT CAP ☐ SWITCH ☐ VOLTAGE____

COOLING SPRAYS____QUANTITY____CAPACITY G.P.M. @ 10 P.S.I.____SIZE I.P.S.____

OTHER EQUIPMENT

LIGHTS:____ QUANTITY____WATTS____CATALOG NO.____

QUANTITY____WATTS____CATALOG NO.____

DIVING BOARDS: COCO MATTING ☐ DOWELED ☐ QUANTITY____LENGTH____CATALOG NO.____

DOUGLAS FIR ☐ ALUMINUM ☐ FIBERGLASS ☐ QUANTITY____LENGTH____CATALOG NO.____

BOARD SUPPORTS:____QUANTITY____HEIGHT____CATALOG NO.____

ADJ. FULCRUM ☐ S.S. ☐ BRASS C.P. ☐ GALV. STEEL ☐ QUANTITY____HEIGHT____CATALOG NO.____

LADDERS:____RAIL SIZE____QUANTITY____TREADS____CATALOG NO.____

DECK ANCHORS ☐ S.S. ☐ BRASS C.P. ☐ GALV. STEEL ☐ QUANTITY____TREADS____CATALOG NO.____

LIFE GUARD CHAIR: S.S. ☐ BRASS C.P. ☐ GALV. STEEL ☐ QUANTITY____UMBRELLA____CATALOG NO.____

LIFE LINE: QUANTITY____LENGTH____FLOATS____ANCHORS____ROPE HOOKS____

RACE LINES: QUANTITY____LENGTH____FLOATS____ANCHORS____ROPE HOOKS____

VACUUM CLEANER____HEAD SIZE____HOSE SIZE____LENGTH____

WALL BRUSH ☐ LEAF SKIMMER ☐ HANDLES____LENGTH____HANDLES____LENGTH____

FILL SPOUT ☐ SIZE____ EQUIPMENT CART ☐ TEST SET: DUPLEX ☐ SINGLE CHLORINE ☐ SINGLE PH. ☐

CHEMICALS — CHLORINE____SODA-ASH____ALUM____ACID____ALGAE CONTROL____

POOL SERVICE ☐ ____ OTHER____

____ OWNER'S SIGNATURE

____ CONTRACTOR'S SIGNATURE

(1) If construction is noted, the health department can request plans from the contractor.

(2) If construction is planned but not yet in progress, the health department can request the cooperation of the prospective owner in obtaining plans.

3. Rules of Thumb for Plan Review - If a health department gains the reputation for the following items in reviewing plans, their success in getting to play a part in construction planning should be good:

   a. Plans are processed quickly.

   b. The health department's regulations are applied uniformly to all situations.

   c. A firm, but understanding, application of rules is made.

   d. Health department plan review personnel have a good understanding of pool design and layout methods.

   e. The health department gives assistance to prospective builders in clearing plans with other official departments.

D. IT CONDUCTS FOLLOW-UP ON CONSTRUCTION OF NEW AND REMODELED POOLS

1. Checks During Construction

   a. Health department representatives should make periodic checks of construction and record agreed-upon variances from the plan.

   b. Health department representatives may make construction checks in the company of members of other official departments such as building and fire departments.

2. Check at Construction Completion

   a. Before granting permission to operate, a final check of all facilities should be made by the health department.

3. Checks After Construction

   a. As a part of the routine pool inspection program, construction details should be noted for application in other pools.

E. IT PROVIDES INSPECTIONAL SERVICES

1. Public and Semi-Public Bathing Places - These pools should be inspected before opening, during operation, and at closing time.

2. Private Bathing Places - Inspection of these pools is usually on a request or complaint basis, depending on the work load of the department.

F. IT DEVELOPS AN EDUCATIONAL PROGRAM

1. Public - Instruction of the public might include information on unsafe bathing places and practices, and the importance of good facilities from a public health standpoint.

2. Pool Contractors - Instruction of pool builders can often eliminate construction difficulties, and also serve to educate health department workers.

3. Pool Operators - Proper operation of pools reduces the work load of the health department.

4. Health Department Personnel - A well-informed sanitarian or sanitary engineer is able to perform more efficiently both for the health department and for the pool owner or contractor.

III. TYPES OF SWIMMING PLACES

A. NATURAL OUTDOOR PONDS, RIVERS, AND TIDAL WATERS - This type of swimming area is difficult to control from a sanitary standpoint.

B. OUTDOOR POOLS, PARTLY ARTIFICIAL, PARTLY NATURAL - This type of pool is common in summer camps and is also difficult to control from a sanitary standpoint. A typical example would be the widening of a stream bed with masonry units and using the stream flow to control water conditions.

C. POOLS, OUTDOOR OR INDOOR, ENTIRELY OF ARTIFICIAL CONSTRUCTION

1. Fill and Draw Pools - This type of pool depends on frequent emptying and refilling to maintain sanitary conditions.

2. Natural Flow-Through Pools - This type of pool is similar to that described in "B," but generally is a more sanitary structure because of its more regular construction features. It depends on the flow of a stream, lake, or flowing well which has been diverted to flow in and out of the pool.

3. Artificial Flow-Through Pools - This type of pool is similar to that pool described in "C-2," but it is generally furnished with more suitable appurtenances for directing flow in, through, and out of the pool. Even so, uniform distribution of pool water is difficult to attain.

4. Recirculatory Pools - This type of pool is the most satisfactory from the public health standpoint. It has, as part of the pool, equipment which filters and recirculates pool water to maintain good water quality.

IV. BASIC PRINCIPLES FOR HEALTHFUL SWIMMING

A. CONTROL THE INTRODUCTION OF DIRT AND INFECTIVE MATERIAL INTO THE POOL

1. Personal Cleanliness of the Swimmers is Important.

2. Proper Design Features Preclude Introduction of Surface Drainage, Sewage Pollution, Wind-Blown Debris, Sand, Dirt, or Vegetation From Surrounding Areas.

B. DIRT AND INFECTIVE MATERIAL WHICH ENTERS THE POOL IS REMOVED OR DESTROYED AS RAPIDLY AS POSSIBLE

1. Continuous Disinfection of Pool Water Helps Maintain Suitable Conditions.

2. Recirculation and Filtration at an Adequate Rate Maintains Good Water Conditions.

3. **Adequate Provision for "Swimmer Numbers Control" Permits Disinfection and Filtration Equipment to Work Efficiently.**

4. **Dilution by Emptying or Continuous Addition and Waste of Pool Water in Pools Other Than of the Recirculatory Type Helps Maintain Water Quality.**

C. POOL CONSTRUCTION AND POOL OPERATION ARE SAFE

1. **Pool Equipment and Appurtenances are Safe**

2. **Swimmers are Supervised at all Times.**

D. PUBLIC HEALTH AND SAFETY PROVISIONS DO NOT PRECLUDE THE ENJOYABLE USE OF SWIMMING FACILITIES

REFERENCES

American Public Health Association; Recommended Practice for Design, Equipment, and Operation of Swimming Pools and Other Public Bathing Places; American Public Health Association; New York, New York; 1957.

Cockburn, T. A., et. al.; "Human Leptospirosis associated with a swimming pool, diagnosed after eleven years"; American Journal of Hygiene; Vol. 60; No. 1; July, 1954.

State of Illinois Department of Public Health; Sanitary Requirements for Swimming Pools; State of Illinois; Springfield, Illinois; 1951.

Williams, H. R.; et. al.; "An epidemic of canicola fever in man with the Demonstration of Leptospira canicola infection in Dogs, Swine, and Cattle"; American Journal of Hygiene; Vol. 64; No. 1; July, 1956.

Lecture Outline

CONSTRUCTING AND REMODELING A PUBLIC SWIMMING POOL AND BATHHOUSE

I. BASIC CONSIDERATIONS OF RECIRCULATORY POOLS

A. POOL FACILITIES LAYOUT (See Figure 1)

1. Bathhouse - This central area has facilities to regulate the issuance, return, and storage of clothes baskets or bags and to handle pool admissions, etc. Its dressing rooms should be designed to permit supervision of cleansing showers and egress to the pool through toilet facilities.

2. Equipment Room - The recirculation and filtration equipment is within easy access of the pool proper.

3. Chlorine Room - Application equipment for disinfectants is kept separate from all other activities.

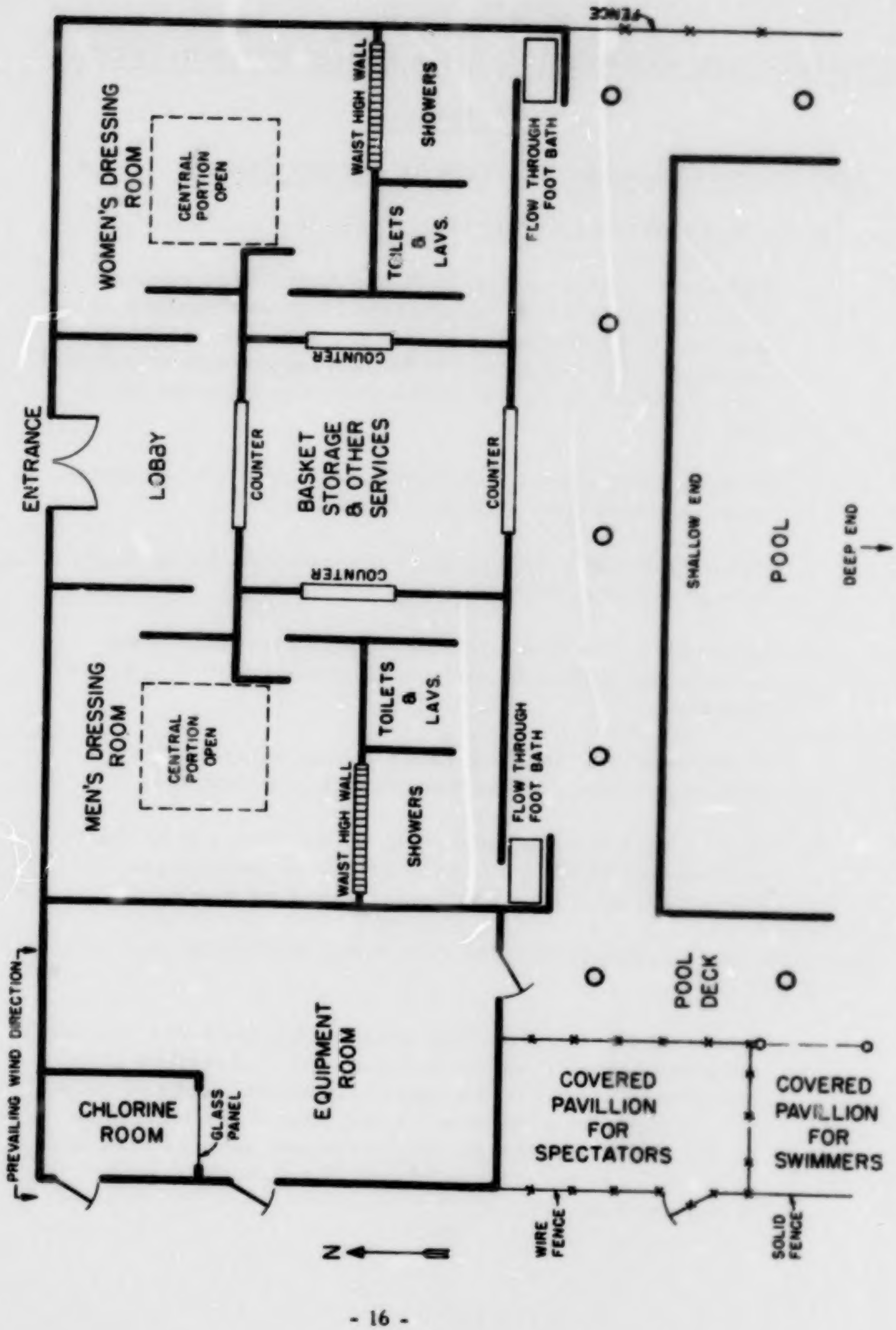
4. Spectators' Pavilion - Spectators are prevented from entering the pool area but are afforded a shaded observation area.

5. Swimmers' Pavilion - A covered area adjacent to the pool is provided for the convenience of swimmers.

6. Pool - Egress to the pool from the bathhouse is at the shallow end of the pool. The bathhouse and equipment room also shield the pool from prevailing winds.

B. POOL STRUCTURE DESIGN AND POOL FITTINGS (See Figure 2)

1. Basic Pool Structure - The pool is composed of a shallow area and a deep area and is fitted with an overflow gutter completely around its periphery. The side and end walls are straight for a depth of not less than 2 1/2 feet. The bottom of the shallow portion of the pool (approximately 70% - 80%) slopes gradually until it meets the deep or diving portion.

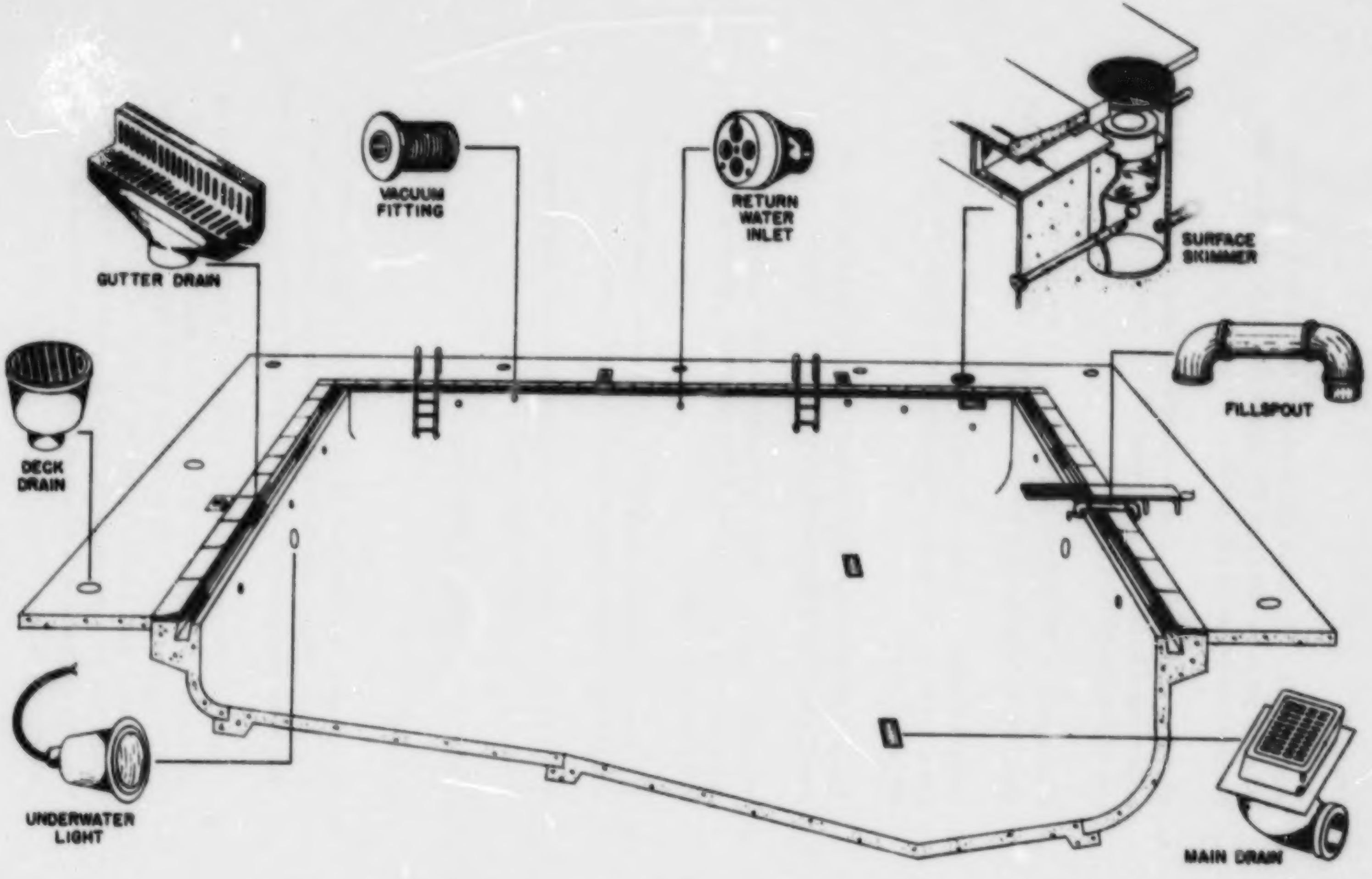


TYPICAL PLAN OF POOL SERVICE FACILITIES

FIG-1

ATLANTA, GA. FEB. 1960

DHEW-PHS-BSS-CDC



LONGITUDINAL SECTION THROUGH POOL SHOWING FITTINGS
FIG-2

DHEW-PHS-859-CDC

ATLANTA, GA. FEB. 1966
[illegible]

2. Fittings

a. Main drain - A large part of the water to be recirculated passes through the main drain located in the deepest portion of the pool.

b. Surface skimmer - This optional fitting recirculates a portion of the surface water from its position at the overflow level of the pool.

c. Fill spout - This fitting serves as a point for introduction of fresh water, and original filling of the pool.

d. Gutter drains - These fittings are located in the overflow gutters to conduct the overflow water to re-use or disposal.

e. Deck drains -Drainage from the pool deck area is conducted to disposal through these fittings.

f. Vacuum fitting - The removable cap on this fitting permits the attachment of a vacuum cleaning device for pool cleaning.

g. Return water inlets -These adjustable flow inlets direct the return water back into the pool.

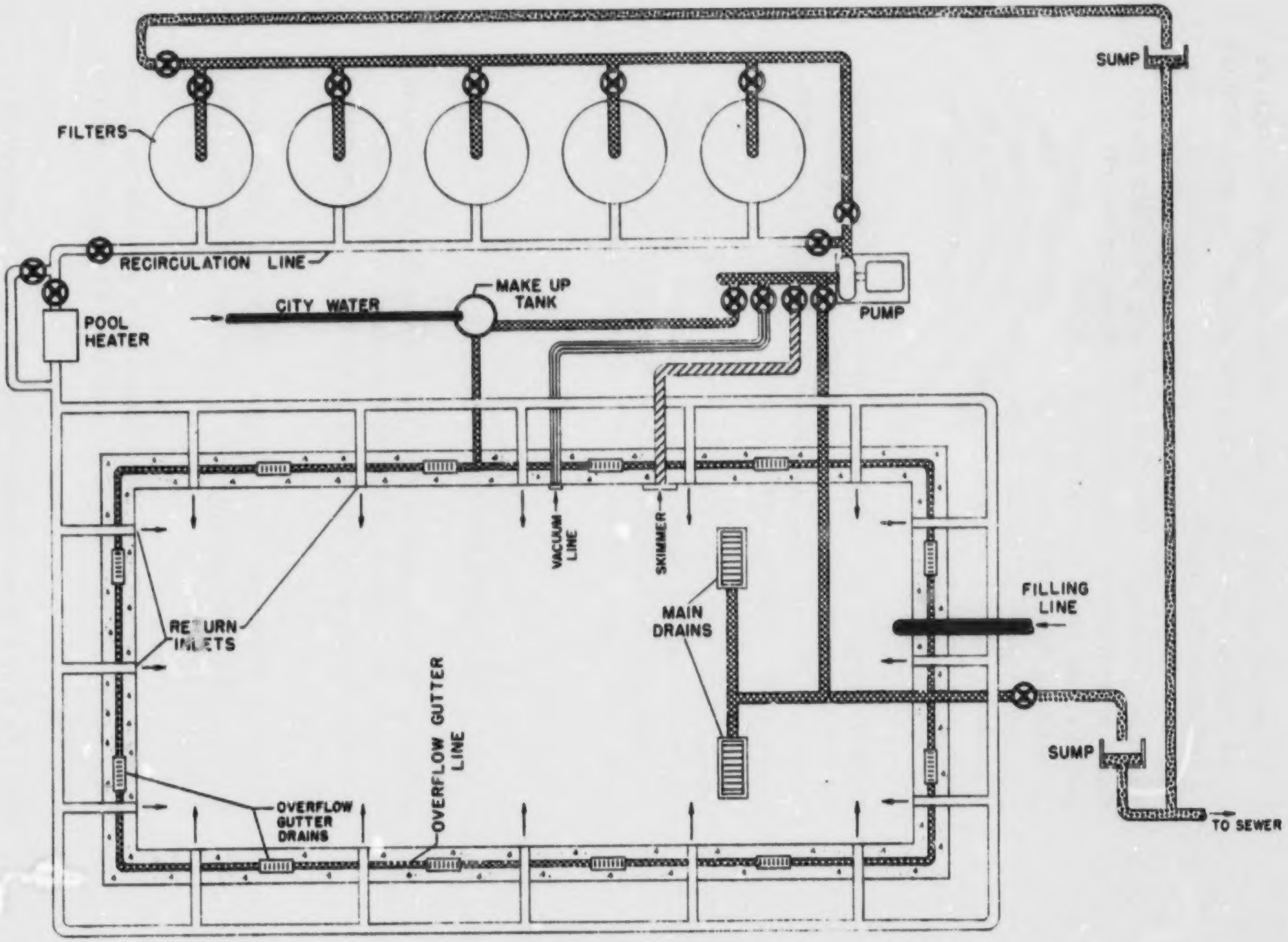
h. Underwater lights - These devices are important adjuncts to night swimming.

C. WATER FLOW PATTERN (See Figure 3)

1. Filtering

a. From pool to filters - Pool water is withdrawn from the main drain and from the skimmer units through the hair strainer by a pump and delivered to the filters.

b. From overflow gutters to filters - Water is picked up at the top surface of the pool by a gutter completely circling the pool. Outlet drains in the gutter collect the water and carry it either to the sewer by gravity, or to the pump intake through a make-up tank. Water lost in splashing and evaporation is also added at the make-up tank.



SWIMMING POOL PIPING SYSTEM

FIG. 3

DHEW-PHS-BSS-CDC

ATLANTA, GA. FEB. 1958
58-264

c. From filters back to pool - Filtered water is delivered through the filters and returned to the pool through return water inlets.

2. Vacuum Cleaning - The lines leading from the main drain and skimmers are throttled down or cut off and the line from the vacuum connection is opened, permitting the pump to pull through this line. The vacuum cleaner attached to the vacuum connection, therefore, can remove dirt from the pool sides and bottom and carry it to the filters, along with a quantity of pool water.

3. Backwashing - Pool water is withdrawn from the pool as for a normal filtering operation, but the flow is reversed through the filters and the accumulated dirt is washed out to the sewer.

4. Initial Pool Filling - Pool water is added through an air break inlet fill spout from the fresh water supply. In some pools it may be added through the make-up tank to be filtered before being dumped into the pool.

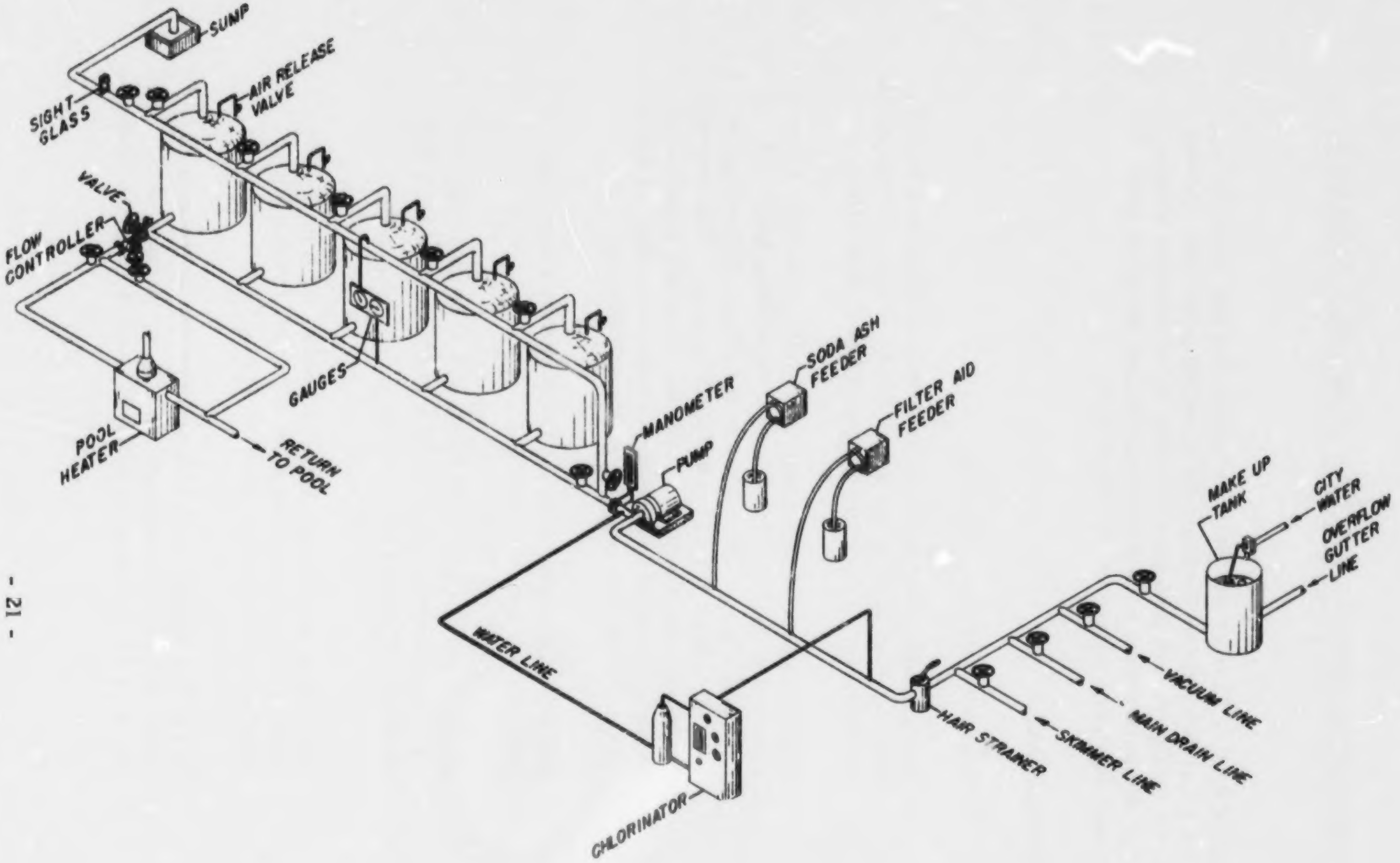
D. FILTRATION EQUIPMENT (See Figure 4)

1. Make-up Tank (Balance Tank) - This tank may provide for continual addition of make-up water for the pool and also serve as a receiving point for overflow gutter water.

2. Chemical Feeders - Coagulants, filter aid, pH control agents, and disinfectants are important adjuncts to the filtration system.

3. Filters - A variety of filter types may provide for constant water filtration. They are also equipped for backwashing.

4. Pool Heater - Water temperature may be maintained during cooler weather for both indoor and outdoor pools with this piece of equipment.



SWIMMING POOL EQUIPMENT ROOM

FIG.- 4

DHEW-PHS-BSS-CDC

ATLANTA, GA. MARCH 1958
58-254

II. DESIGNING POOL SIZE TO FIT THE EXPECTED SWIMMING LOAD

A. GENERAL - This is not primarily an attempt to arrive at a limit for patron load for an existing pool (See lecture notes on Operation and Maintenance of Swimming Pools, page 81) but rather a method of designing the pool area to fit the expected numbers of swimmers.

B. DESIGN DATA

1. Estimated Expected Loading

a. Large public pools - Information on expected loading may be obtained from pools in the same general area, or from local recreation department statistics.

Cities under 30,000 population will generally have a maximum daily attendance at swimming pools of between 5% and 10% of the population. This figure will decrease for larger communities. The average daily attendance is about 2% to 3% of the population. Peak attendance in the pool at any one time is about one-third of the average daily attendance.

Neighborhood pools draw their patrons from an area of 3 1/2 miles radius.

Larger pools draw their patrons from an area of seven miles radius with 50% of them coming from an area of two miles radius.

b. Small public or semi-public pools (such as a motel pool) - Experience may be obtained from other similar pools in the general area.

A rule of thumb sometimes used for motels is to allow for one person per unit up to 50 available units, and one person for each additional two units.

2. Swimming Limit (APHA) - (See example problem page 59.)

   a. Diving area - A maximum of 12 persons is permitted for the area within 10 feet of each diving board or platform.

   b. Swimming area - This area, which is defined as that part of the pool deeper than 5 feet from which the diving area has been subtracted, can support one person for each 24 square feet.

   c. Non-swimming area - For large outdoor pools, 70% to 80% of the pool area should fall into this category. Ten square feet per person in this part of the pool is the maximum limit. Areas shallower than 2 feet should be confined to spray (wading) pools.

III. SANITARY CONSTRUCTION REQUIREMENTS

A. POOL WATER SUPPLY

1. Quality - The water supply must be of a quality that will permit adherence to the rigid bacteriological standards for pool water. (See lecture outline "Inspection of Pool Installations and Bacteriological Sampling of Public Swimming Pool Waters", page 123)

2. Chemical and Physical Properties - The chemical and physical properties of the water should be that of drinking water. Low turbidity (less than 10 ppm), above neutral pH, and absence of harmful chemical levels are imperative for good operation.

3. Water Quantity - The quantity available is important in that limited quantity dictates excessive pool filling times.

4. Protection of Supply System - The water supply system must be a sanitary installation. For well supplies, as an example, this will include among other things

provisions for protection against surface contamination.

5. Introduction of Supply Water - Introduction of fresh and make-up water must protect against back-siphonage by use of an air gap or vacuum breaking device.

B. POOL AND POOL AREA

1. Construction

   a. "Poured" concrete - This type of construction permits inclusion of recessed areas and allows for complete water drainage during periods of non-use.

   b. Prefabricated steel or plastic - This type of construction may be the least expensive for initial installation, but has some drawbacks in maintenance.

   c. "Gunite" concrete - This method of spraying concrete into a pre-formed excavation is less expensive than the "poured" pool, but permits less variation in pool design such as vertical wall construction, due to its dependence on arch construction for structural strength.

2. Pool Wall and Floor Surface - A smooth, impervious surfacing is required for all pool water contact areas.

3. Pool Wall and Floor Color - The use of a light-colored finish is indicated for safety and sanitary reasons.

C. POOL SHAPE, DESIGN AND FLOOR SLOPES

1. Outlet Drain - The outlet drain should be provided at the deepest portion of the pool. It should also be provided with piping so that the pool may be emptied in 4 hours or less.

2. Side and End Walls - These walls must be vertical for a depth of not less than 2 1/2 feet, and rounded or coved at wall-floor joints. Deep area safety ledges constructed 4 feet below the water surface are sometimes used. These are made 4 to 6 inches wide, sloping 1/2 inch toward the pool.

3. General Pool Dimensions - Pool lengths should ordinarily not be less than 40 feet, and the width should be some multiple of 5, 6, or 7 feet. The area of shallow water (5 feet or less in depth) should make up from 70% to 80% of the total pool area.

4. Floor Slopes - The slope of the pool floor should not be greater than 1 foot in 15 feet where the water depth is less than 5 1/2 feet. Furthermore, there should be no sudden changes in slope for this area. In pools of less than 42 feet overall length, the rate of slope may be increased to a maximum of 1 foot in 8 feet.

D. POOL DECK AREA

1. Depth Marking - Marking of 4" minimum height, visible both by day and under artificial lighting, should be placed at regular intervals at the pool periphery, spaced at not more than 25-foot increments. Even small pools should have the markings at the deep and shallow ends as well as at the 5-foot point.

2. Runway - The pool must be surrounded by an impervious apron extending at least 4 feet away from the pool edge. Widths of 8 to 10 feet are preferred.

3. Drainage - The deck area should slope away from the pool at about 1/4 inch per foot and be provided with one floor drain for each 100 square feet of surface.

4. Sunbathing and Resting Areas - It is desirable to include a shaded area for the convenience of the pool patrons, but all grass, shrubs, overhanging trees, overhanging electrical wiring, and sand areas should be scrupulously avoided in the pool area.

E. OUTLETS

1. Main Drain Size - The main drain and its piping must be of a size to permit emptying the pool in 4 hours. Its easily visible outlet grating should have an area of openings four times the area of the discharge pipe to preclude objectional suction effects. Some drains are marked with a dark colored circle, if not constructed of shiny metal.

2. Main Drain Location - The main drain outlet system located in the deepest section of the pool should be provided with more than one outlet point if the pool width is in excess of 20 feet. These outlets should be no farther apart than 20 feet on center and no closer than 10 feet from the side walls.

3. Pool Waste Water - If water discharged from the pool is to be conveyed into a public sewerage system, it must be protected by an air gap entrance to preclude back-siphonage. The additional provision of a sand trap sump may also be advisable.

F. RETURN WATER INLETS

1. Type of Inlet - The inlets should be of adjustable flow construction, and they must be suited to the area of the pool which they serve so that an even distribution of water is provided. One type adjusts flow by changing internal orifices (Kane Jet-Flo), while others adjust flow by revolving a face plate (*i. e.*, Paddock adjustable inlet).

2. Number and Location of Inlets

    a. General - All inlets should discharge at a depth of 10 to 15 inches below pool overflow level to prevent loss of disinfectant and excessive odor formation.

    b. Large pools - In this type of pool with outlets near the center of the pool, inlets should be placed on about 20-foot centers entirely around the perimeter of the pool.

    c. Smaller pools - When the distance across the shallow end is as great as 15 feet, multiple inlets at the shallow end should be provided. These inlets must serve not more than 15 linear feet. In spoon shaped rectangular pools where outlets are located more than 5 feet from the end walls, inlets must be placed at both ends of the pool.

d. Maximum flow rates - The maximum flow rates through various sized inlet branches should not be more than listed below:

Inlet size (inches)	1	1 1/4	1 1/2	2
Flow rate (GPM)	10	20	30	50

G. LIGHTING

1. Pool Area Lighting - Adequate lighting in the pool area is a necessary safety adjunct to successful night use of pool facilities. A level of at least 5 foot candles is desirable. In indoor pools, window or skylight areas should have an area of at least 1/2 of the pool area, including runways. No electrical wiring for power or lighting should be permitted to pass overhead within 20 feet of the pool enclosure.

2. Underwater Pool Lighting - This type of lighting installed beneath the pool water surface provides a means of supervising the safety aspects of swimming as well as creating an attractive swimming site. These lights must be carefully protected against short circuits. Not less than 0.5 watts per square foot of pool area is one standard used in choosing underwater lights.

H. HOSE CONNECTIONS

1. Size and Number - Hose bibs of one inch size for flushing and cleaning should be provided at the pool deck area. They should be spaced at such intervals that would allow parts of the pool deck area to be reached with a 50 foot hose. Additional smaller hose bibs should be provided for the same purpose in the equipment room and in both dressing rooms.

2. Water Pressure - A pressure of at least 20 pounds per square inch should be available at the hose extremity to develop sufficient force for maintenance operations.

I. OVERFLOW GUTTERS

1. Purpose - The gutter serves as an adjunct to pool egress and as a place for swimmer expectoration. It also provides an overflow for pool water.

2. Location - These overflow or scum gutters should be installed completely around the periphery of the pool on a uniform level.

3. Dimensions and Slopes - The minimum depth should be about 2 to 3 inches to provide a suitable hand-hold. They should further be fully open for ease of cleaning and to prevent accidents. The gutter bottom should slope 1/4 inch per foot to gutter drains.

4. Gutter Drains - These fittings preferably of the 90° degree angle type (see Figure 2), which reduces clogging difficulties, are located on 10 to 15 feet centers in the gutter bottoms. They should be provided with drain lines with a 2 1/2 inch minimum diameter.

5. Special Gutters - The "water-level deck type" swimming pools are constructed with the water level maintained about flush with the peripheral overflow around the entire edge of the pool. Water is flushed over the edge of the sides and ends of the pool onto a floor which is sloped toward deck drains spaced at 15 feet intervals and covered with gratings. Cuspidors are built into the floor at each end of the pool for expectoration. Egress from the pool is by a kicking and rolling motion. This type of construction violates a strict interpretation of item I-2.

J. SURFACE SKIMMERS

1. Purpose - They are installed on private pools to supplant the overflow gutter and yet serve to recirculate a portion of the surface water. On public pools they may serve as an adjunct to or a replacement for the overflow gutter if permitted by local regulations.

2. General Operation - From a position just below the pool deck, these devices which may be used individually, in pairs, or at uniform spacing completely around the pool; recirculate a large volume of the water by means of a

water adjusted flapper gate. Debris is caught in a wire basket while the water is conducted to the filtration pump suction.

3. Installation Requirements (if used in lieu of overflow gutters)

   a. Number installed - At least one skimming device should be provided for each 800 square feet of pool surface area or fraction thereof. One skimmer should be placed at a point in the pool opposite the direction of prevailing summer winds.

   b. Operational criteria - They should each be designed for a flow-through rate of at least 30 gallons per minute and all skimmers in the pool should be capable of handling approximately 50% of the required filter flow of the recirculation system. The overflow weir should be of sufficient length to maintain a rate of flow of at least 20 gallons per minute per linear foot of weir lip.

   c. Equalizer line installation - This line is of a 2" minimum size and is installed at least one foot below the overflow level of the skimmer to prevent "airlock" in the suction line if the pool water level should drop below the weir level.

K. STEPS AND LADDERS

1. General - A means of egress must be provided at the deep end of the pool and also at the shallow end if the distance from runway to pool bottom is more than 2 feet. One mode of egress should be provided for each 75 feet of pool perimeter and not less than two in any case.

2. Steps - Steps must not project into the pool proper. If step holes are used they must be provided with drainage and non-slip surfacing. Hand rails are required with step holes.

3. Ladders - If ladders are used they must not project too far into the pool proper. Each ladder must be equipped with a handrail.

L. POOL LOCATION AND SURROUNDINGS

1. General - The pool should be located away from untreated roads, smoky industrial areas and dusty parking lots and playgrounds. The pool buildings should shield the pool from prevailing summer winds.

2. Fencing - A wall or other enclosure of 4 foot minimum height is a desirable adjunct to pool operation.

3. Sand Areas and Vegetation - Grass, earth, and sand areas must be excluded from the pool area. Overhanging foliage must also be eliminated.

4. Spectators' Area - All observers in street clothes must be kept out of the swimmers' area. Covered pavilions will provide for spectators' comfort.

5. Drinking Fountains - Angle jet, anti-squirt type drinking fountains should be provided for the pool and bathhouse. Care should be taken not to choose a frost proof fountain that is subject to back siphonage.

6. Waste Receptacles - Mail-box type waste receptacles will do much to eliminate scattered litter in the pool area.

M. DIVING BOARDS AND FLOATS

1. Headroom - For indoor pools at least 13 feet of headroom above the highest diving board must be provided.

2. Diving Area - The depth of the pool adjacent to diving platforms or floats should conform with the following table:

Elevation of Diving Board Above Water (feet)	Minimum Diving Depth (feet)
3	8
5	9
7	11
10	12

N. SPRAY (WADING) POOLS

1. General - Separate pools for small children and of a depth of 2 feet or less may be constructed as an auxiliary unit of the pool proper.

2. Water Flow and Treatment

   a. Spray pool - The most suitable type of unit is one designed to spray fresh (or recirculated) water over the area and waste (or recirculate) it rapidly.

   b. Fast flow-through pool - Wading pools designed as flow-through pools will function satisfactorily if the water depth is very shallow, and if the rate of flow provides a rapid turn-over of pool contents. This type of design is only recommended as a remodeling measure when reconstruction of an existing wading pool to a spray pool is impractical.

   c. Water treatment - Water for this pool can be recirculated with the fresh (or make-up) water or continuously wasted. The latter method is preferred if a suitable means of auxiliary disinfection can be supplied.

O. LIFE GUARD STANDS - One lifeguard chair should be provided for each 2,000 square feet of pool surface area or fraction thereof. If a pool has a width of 40 feet or more and is provided with more than one lifeguard stand, these stands should be located on each side of the pool.

P. RECIRCULATION SYSTEM AND APPURTENANCES

1. General Factors Affecting Size of System - (See Illustrative Problem - "Calculations - Review of Swimming Pool Plans", page 61)

   a. Volume of pool - The greater the volume of water, the larger the system necessary.

   b. "Turnover ratio" - The number of times in 24 hours that the contents of the pool are recirculated will effect the size of the treatment system. A turnover ratio of 3 or 4 is desirable for public pools.

c. Hydraulic factors - The choice of system size will also be dependent upon the hydraulic factors listed below:

(1) Horizontal distance of the filtration system from the pool.

(2) Vertical distance of the filtration system above the pool.

(3) Number of ancillary units such as pool heaters, included in the system.

2. Pumping Equipment

a. Type of Pump or Pumps - The usual pump used is a centrifugal pump capable of providing 2 to 3 gallons per minute per square foot of total filter area. For backwashing, separate pumps are sometimes used, but this is not generally the case. If the pool does not drain by gravity, the pump must also be able to empty the pool in 4 hours.

b. Size of pump

(1) Empirical calculation - The following formula may be used to determine pump size:

$$\text{Horsepower required} = \frac{\text{Gallons per minute pumped} \times \text{Total pumping head in feet}}{3960 \times \text{Pump efficiency}}$$

(2) Rules of thumb

(a) Pressure sand filter system - A pump large enough to operate against a 50-foot head will generally be suitable.

(b) Pressure diatomaceous earth filter system- A pump large enough to operate against a 100-foot head will generally be suitable.

(c) Vacuum cleaning attachment - The pump must pull at least 4 gallons per minute per lineal inch of opening in the vacuum cleaning head while operating at a total vacuum (at pump suction) of 15 feet of water.

3. Hair Strainer

   a. Purpose - This device protects the pump from clogging and damage from hair, lint, pins and other foreign material. It is placed between the pool outlet and the suction side of the pump.

   b. Construction - The removable portion of the strainer should be constructed of non-corrosive material. The holes in this unit should not be more than 1/8 of an inch in diameter and the area of all of the holes should be at least 10 times that of the inlet area.

4. Coagulation (for Sand Filters) and pH Control (for All Filters) Feeding Equipment

   a. Purpose of equipment

      (1) Coagulation equipment - Alum and other coagulant chemicals help filtration by assisting in coagulating impurities and by forming a mat on top of the filter bed.

      (2) pH control equipment - Soda ash, lime and other chemicals are fed to maintain optimum water pH.

   b. Types of dispensing equipment

      (1) Dry feed machine - These devices automatically measure and weigh the pulverized dry chemical and are equipped with continuous dissolvers. They are the most efficient of all chemical feed devices.

      (2) Dissolving device - These are the same as described for hypochlorite application. (page 47)

      (3) Pressure solution feeder ("Alum Pot") - These are the same as described for hypochlorite application. (page 47)

(4) Positive displacement chemical feed pump - These are the same as described for hypochlorite application on page 48.

c. Rules of thumb for coagulant feeder sizing

Pool volume (gallons)	Volume of Feeder (cu. ft.)
< 50,000	0.1 pot
50,000 - 120,000	0.5 pot
120,000 - 310,000	1.0 pot
> 310,000	2.0 pot (or dry feed and chemical feed pump)

5. Filter Aid (Diatomaceous Earth Filters) Feeding Equipment

a. Purpose of filter aid equipment

(1) Precoat feeder - Diatomaceous earth is fed into the filter to form the prime filtering mat.

(2) Continuous feeder - Diatomaceous earth is fed into the filter to maintain the filtering capacity of the filtering mat.

b. Types of dispensing equipment - These are similar in construction to the devices used to dispense coagulant and pH control materials with the addition of constant mixing devices to keep the diatomite free flowing.

c. Rules of thumb for feeding equipment size

(1) Precoat feeder - The feeder must be large enough to deliver an initial charge of 2 ounces of diatomaceous earth per square foot of filter area.

(2) Body Feeder (continuous feeder) - The feeder must be large enough to deliver 1 to 4 ounces per 1000 gallons of water recirculated per day.

6. Filtration Equipment

a. General - The filtration equipment must be of a size that will permit the filtering of the pool contents within a turn-over ratio of 3 to 4 (6 to 8 hours). Design criteria must include maximum filtration rates of 2-3 gallons per square foot per minute and backwash rates of 10-15 gallons per square foot per minute. All particles down to 10 microns (1/2, 540 th of an inch) in diameter should be removed by a good filter unit.

b. Types of filters

(1) Pressure sand filters

(a) Media - Thirty-six inches of sand with an effective size* of 0. 4 to 0. 5 mm. and a uniformity coefficient** of 1. 75 underlaid with gravel and/or other effective filter media support is required. Anthrafilt if substituted for the sand should have an effective size of 0. 70 to 0. 75 mm. with a uniformity coefficient of 1. 60.

(b) Method of operation - Recirculated water is passed under pressure through the layer of alum floc on top of the sand and then through the sand for filtration. Backwashing requires passing water through the filter in the opposite direction. Eighteen inches of free-board prevents washing away of sand during backwashing.

(c) Tank types - Vertical tanks are used on pools up to 400, 000 gallons in size, while horizontal tanks are used for pools between 300, 000 and 1, 000, 000 gallons.

(d) Accessories

(I) Pressure gauges - Gauges taped onto the influent and effluent lines of the filter should be located together at the same elevation.

---

* Effective size is that size of a grain in a sample of sand such that 90% by weight of all of the grains in the sample are larger.

** Uniformity coefficient is the ratio of that size of grain of which 40% are larger to the effective size.

(II) Air relief valve - This valve located on the top of the filter shell will release entrained air.

(III) Rate of flow indicator - This device permits the flow rates in filtering and backwashing cycles to be read. It should have a range of 10% below the established filtration rate and 10% above the established backwash rate.

(IV) Manhole - The manhole of minimum size, 11" x 15", must be easily accessible and have an easily removable cover for inspection.

(V) Rate of flow controller - Pools of over 100,000 gallons capacity are of a size that warrant the inclusion of a rate of flow controller.

(VI) Sight glass - A sight glass on the backwash line permits observation of the filter cleaning progress.

(e) Comparison of this type of filter with others - This filter is easy to operate in comparison with other types. It will permit rather long filter runs and generally costs less to operate than other pressure filters from the standpoint of power costs. It requires more room than do other pressure filters.

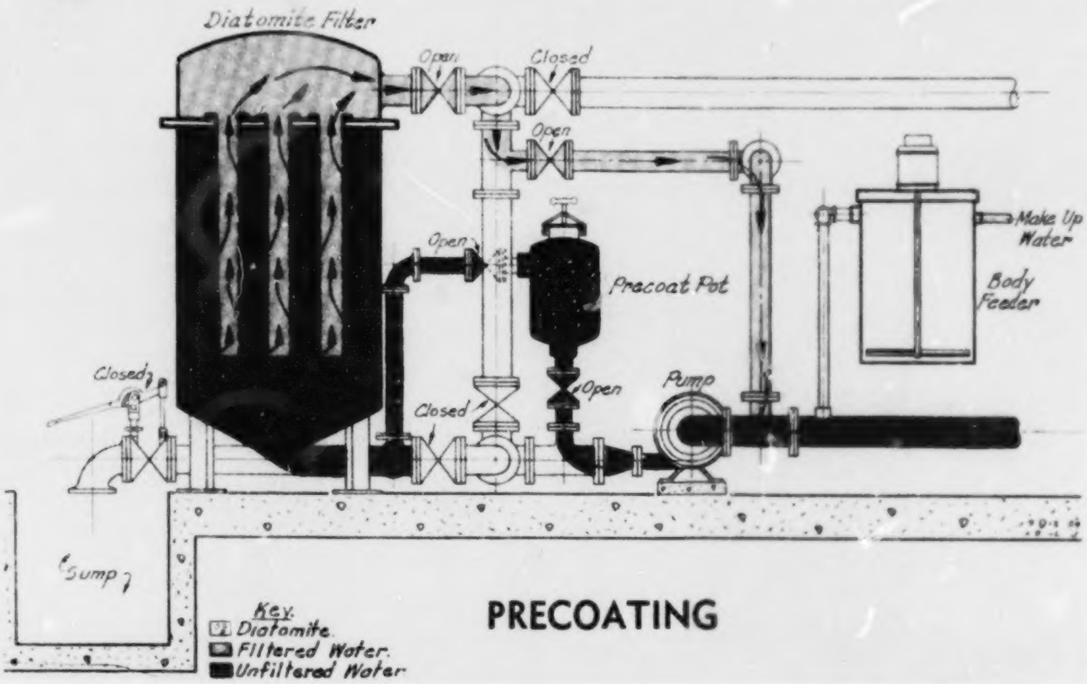
(2) Diatomaceous earth filters (see Figure 5)

(a) Media - Diatomaceous earth, the fossil remains of a microscopic marine plant, is used in a thin coating over filter septa or bags.

(b) Methods of operation - Recirculated water is filtered by passage through a thin coating of diatomaceous earth which is placed on a filter septum (or leaf). These filter septa are provided with openings, the minimum dimension of which should not be greater than 0.005 inches.

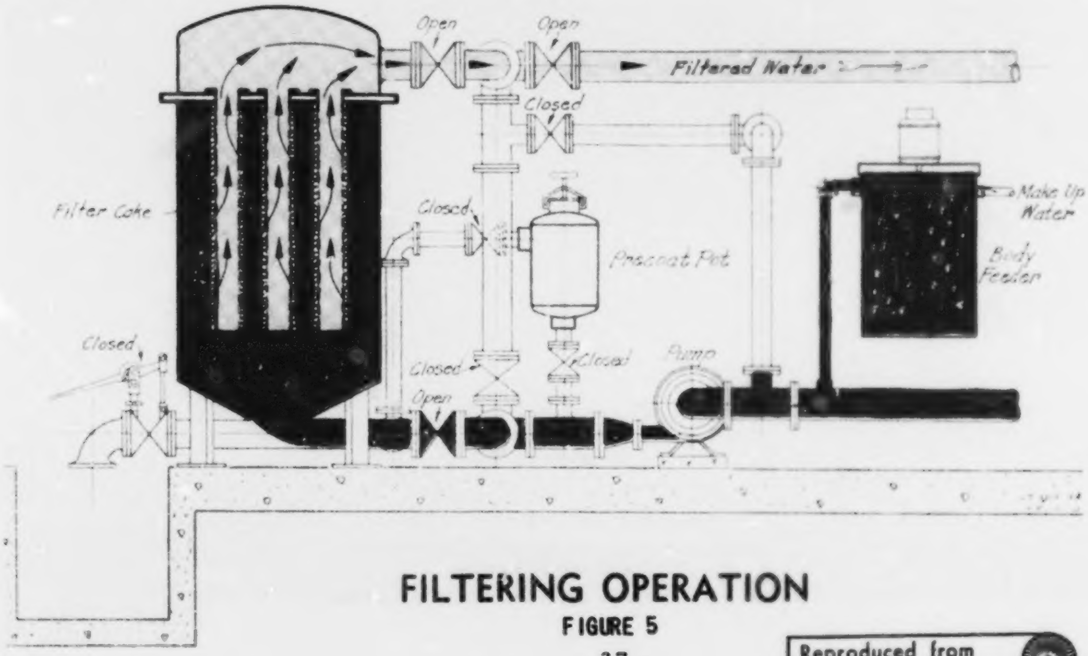
THE DIATOMITE FILTER

FIR[redacted]TEP—Diatomaceous earth is used as a filter aid. In this operation a thin, tight coating of the diatoma material is caught by filter elements and held there by water flow. Precoat charge is generally .125 lbs. omite for each square foot filter area.



PRECOATING

SEC[illegible] STEP—After the precoat is applied and in place, filtered water valve is opened and recirculation valve closed. Water is now being filtered. Additional diatomite is added to the influent water to improve efficiency. This is called "Body Feed." Filtering pores are so fine that effluent is of very high clarity.



FILTERING OPERATION

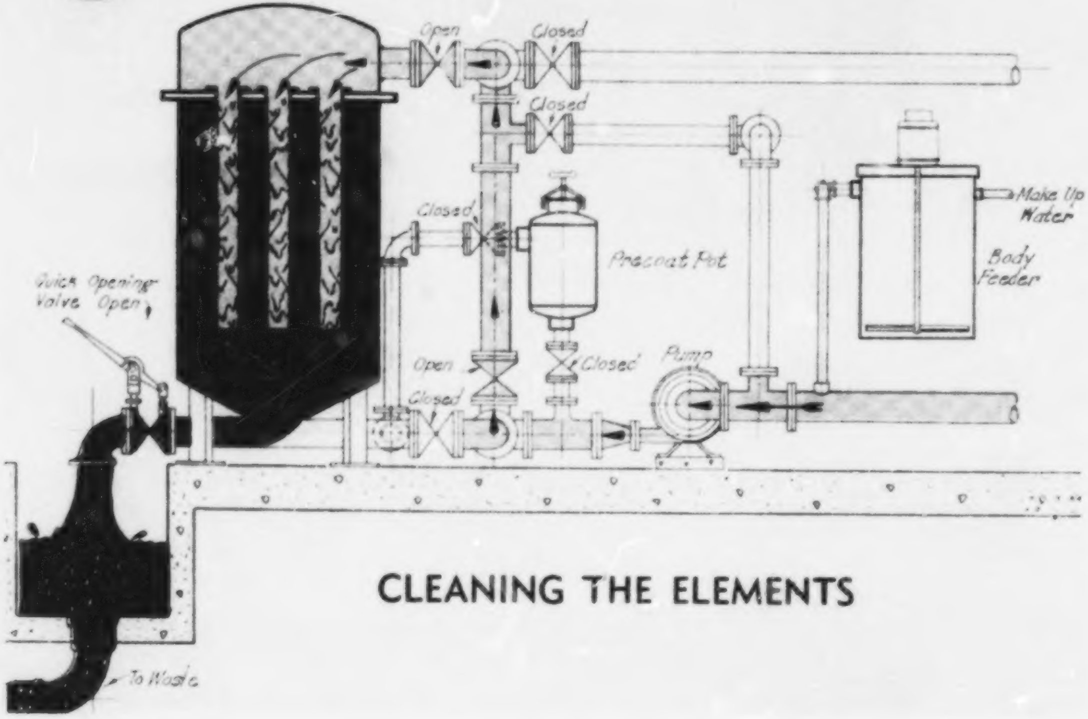
FIGURE 5

Reproduced from best available copy.

FIGURE 5 (Continued)

3

THIRD STEP—After many hours of continuous operation it becomes necessary to clean the elements. This is accomplished in about 2 minutes.



CLEANING THE ELEMENTS

Reprinted with Permission by the
DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
From General Filter Company's Bulletin No. 5502

The filtration may be under positive pressure as with the pressure sand filters, or under a vacuum. In vacuum filters the water is sucked through the filter septa which are submerged in an open basin full of recirculated water. Backwashing is accomplished by reversing flow, by air pressure, or by hand rinsing. The three cycles in the operation of a typical diatomaceous earth filter are shown in Figure 5.

(c) Accessories

(I) Pressure gauges - These are the same as for the pressure sand filter except that they generally must be of a higher reading variety.

(II) Air relief valve - This is the same as for the pressure sand filter.

(III) Rate of flow indicator - This is the same as for the pressure sand filter.

(IV) Manhole - This is the same as for the pressure sand filter.

(V) Rate of flow controller - This is the same as for the pressure sand filter.

(d) Comparison of this type of filter with others - While this filter requires less space and weighs less than others it requires very skilled operation. It uses little wash water and requires no coagulants but uses a continuous supply of diatomaceous earth. Some difficulty has been found with element failure, ease of assembly and frequency of backwashing.

(3) Gravity sand filters

(a) Media - This is essentially the same as for the pressure sand filter.

(b) Method of operation - Recirculated water is passed by gravity through a layer of alum floc on top of the sand and then through the sand for filtration. Backwashing requires passing water through in the opposite direction under pressure.

(c) Accessories

(I) Loss of head gauge - This gauge indicates when the filter is in need of backwashing.

(II) Rate of flow controller - This is the same as noted for the pressure sand filter.

(III) Wash water tank - A tank of sufficient size and of sufficient height above the filter bed is desirable, to deliver water for backwashing. Backwashing may also be accomplished by pumping water directly from the pool.

(d) Comparison of this type of filter with others - The distinct advantage of this filter is that its media can be readily inspected during all stages of operation. It is generally more costly to build, however, and requires skillful operation.

7. Make-Up Tank

a. Purpose - This tank, connected to the suction side of the recirculatory pump, serves as a means of maintaining a constant level of water in the pool. A fresh water connection to this, controlled by a float valve, admits fresh water, when water is lost through evaporation and splash. It also serves as a place for emergency introduction of chemicals.

b. Construction features

(1) Fresh water inlet - This inlet must be protected from back-siphonage by air gap or siphon breaker installation.

(2) Waste fitting - This fitting provides a suitable path for overflow of water from the tank in the event the float does not operate properly. The overflow pipe should not be connected directly to a sewer.

(3) Pool overflow connection - If desired, overflow water passing into the overflow gutters can be directed to flow by gravity to the tank for recirculation through the filter system.

8. Disinfection Equipment

a. Chlorine disinfection

(1) Gas chlorination

(a) General - When a tank of liquid chlorine has its pressure removed, it becomes a gas. The liquid chlorine feeder or chlorinator is a device which can control the change of liquid into gas, the dissolving of the chlorine gas in water, and the proportioning of the chlorine solution to the main flow of water. Some chlorinators apply chlorine gas directly into the main flow of water.

(b) Basic principles involved in chlorine feed control - The top diagram in Figure 6 shows the flow of a fluid through a pipe line. As fluid moves through the line, a pressure drop occurs across an orifice and is indicated by the difference in height of the fluid in peizometer tubes, upstream and downstream of the orifice. The difference in pressure represents a particular flow.

Chlorine application is controlled by varying one condition in such a flow pattern as described below.

(I) Method "A" - Referring again to Figure 6. we see that flow control is basically obtained by setting the downstream conditions constant, as shown by Vc, constant vacuum. The orifice is also maintained constant as shown by O_C. The upstream condition of pressure, shown by P_V, is a variable and this is controlled by the operator, to deliver the desired amount of chlorine.

PRINCIPLES OF CHLORINE GAS FEEDERS

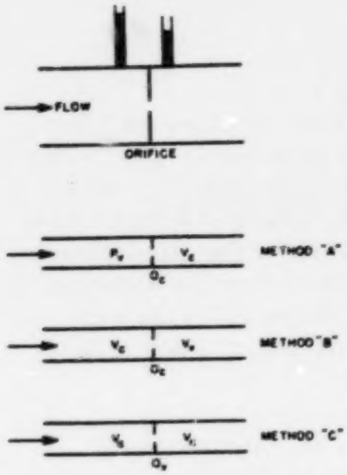


Figure 6. —BASIC PRINCIPLES involved in chlorine feeder design

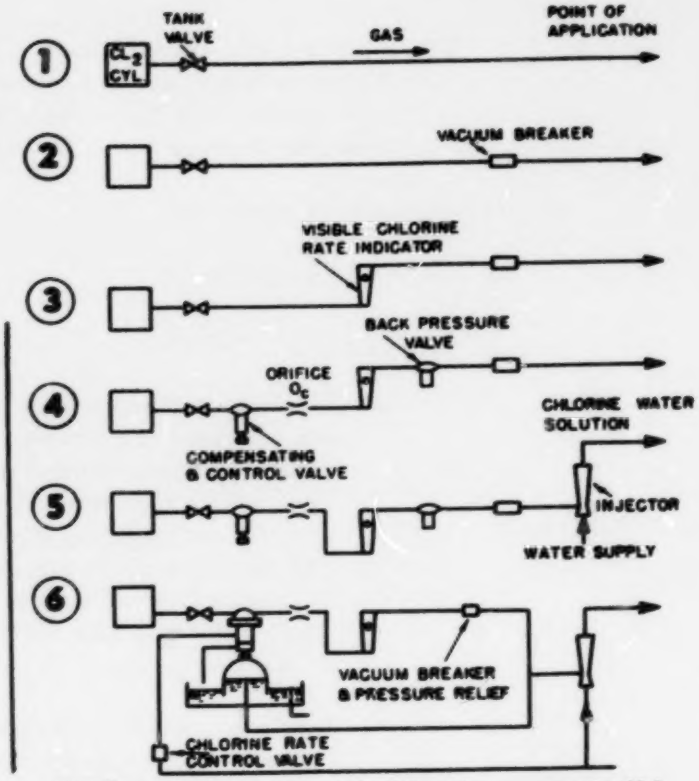
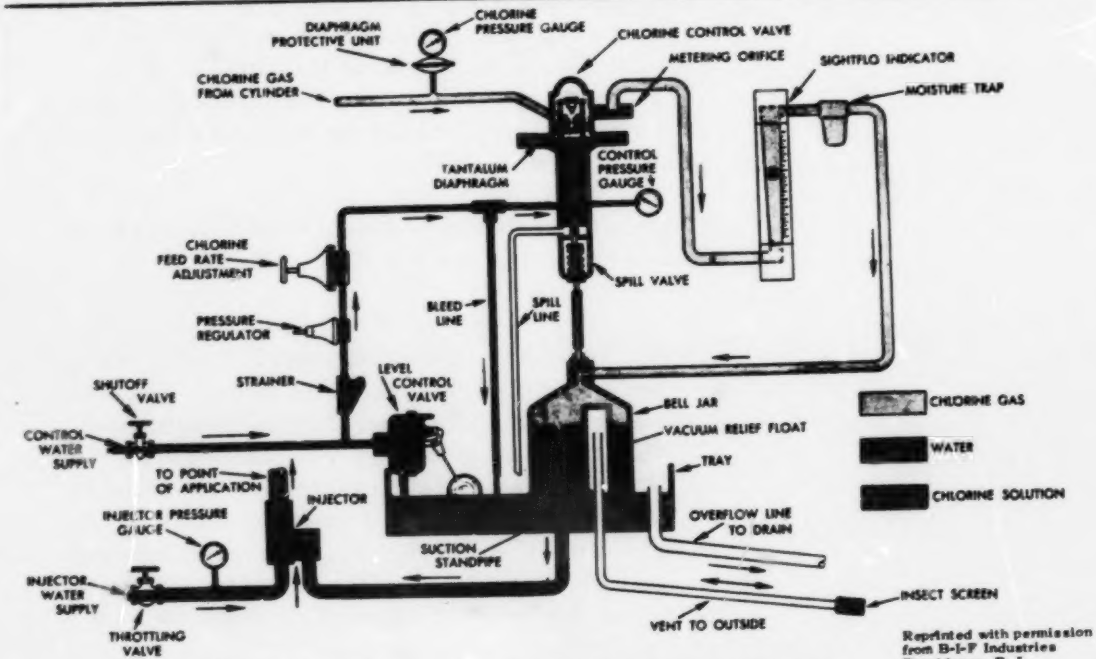


Figure 7. —EVOLUTION of chlorine feeder design as improvements were added



Reprinted with permission from B-I-F Industries Providence, R. I.

Figure 8.—DIAGRAM illustrating the relationship of chlorine gas feeder components

Reproduced from best available copy.

Figure 8 shows a complete flow diagram of one chlorinator of this type.

Figure 9 shows a complete flow diagram of another chlorinator that is basically this type also. It differs only in that the upstream condition is one of vacuum, which is variable.

(II) Method "B" - A second technique of control shown in Figure 6 is to maintain upstream conditions constant as shown by V_c, constant vacuum and also maintain O_c, or constant orifice. The operator delivers the desired flow by varying the downstream vacuum, V_v.

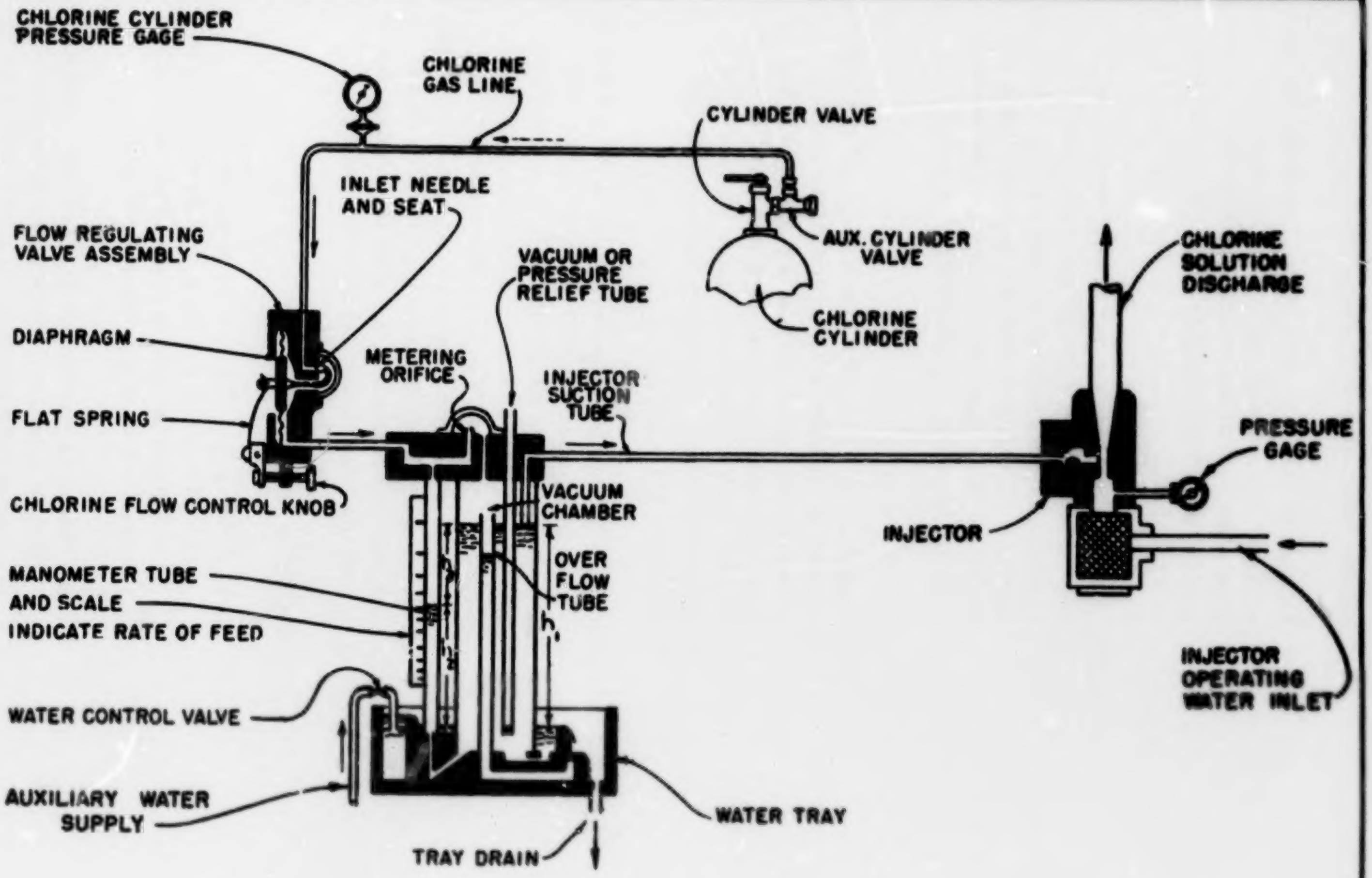
(III) Method "C" - A third technique of control shown in Figure 6 is to maintain an upstream vacuum constant as shown by V_c and a downstream vacuum constant as also shown by V_c. The operator delivers the desired flow by changing the size of the orifice, O_v.

(c) Design of chlorine dispensing devices - Basically, as described above, a chlorine feeder utilizes an orifice of some type in a gas flow line with means for keeping constant certain conditions, and with means for establishing at will other conditions, and maintaining them at the established valve. All other devices which are incorporated in chlorine feeders are included for convenience and safety.

(I) Direct feed types

(A) Simple gas feeder - Diagram (1) in Figure 7 shows chlorine feeding directly from a cylinder with the tank valve used as an adjustable orifice.

(B) Vacuum protected gas feeder - Diagram (2) in Figure 7 shows the addition of a vacuum breaker to prevent water at the



FLOW DIAGRAM
CHLORINATOR
WALLACE & TIERNAN

Figure 8.

point of application from being drawn back into the line.

(C) Gas feeder with flow measuring device - Diagram (3) in Figure 7 shows the addition of a flow measuring device to the vacuum protected simple feeder.

(D) Gas feeder with compensating valves - Diagram (4) in Figure 7 shows the addition of compensating valves, upstream and downstream of an orifice. With these additions to the feeder, constant flow can be maintained regardless of changes at the point of application or in chlorine cylinder pressure.

(II) Solution feed types

(A) Semi-vacuum type - Diagram (5) in Figure 7 shows the addition of an injector which permits the dissolving of a measured amount of chlorine gas in a controlled supply of water. This solution of chlorine can then be delivered into the main water supply. This device can still leak gas in the event of a major break and may still deliver chlorine to the point of application even if the injector supply fails.

(B) Full vacuum type - Diagram (6) in Figure 7 shows a modern feeder in which several additional safety measures have been added. A pressure relief has been added in combination with the vacuum breaker and the compensating valve has been designed so that it will close on loss of vacuum. This later condition might be caused by loss of injector supply, blockage at the point of application, or break in the gas lines.

Constant downstream vacuum is developed through the medium of a standpipe of fixed height within the bell jar (point of mixing of gas with water to form a chlorine colution).

This device operates like method "A" in Figure 6.

(d) Strength of chlorine - Chlorine gas (liquid) has 100% by weight available chlorine.

(e) Size of chlorinator - For swimming pools, a machine should be provided that will deliver 1 pound of chlorine per day for each 10,000 gallons of water in the pool.

(f) Construction safety precautions -

(I) Separation of operations - The chlorinator and all appurtenances must be physically separated from the remainder of the filtering equipment by floor to ceiling air-tight walls.

(II) Chlorine tank - The tank should be strapped to a wall or post if not held in a hole recessed in the floor.

(III) Ventilation should be provided in the chlorine room if it is above ground level. Pit installations must be provided with automatic forced air ventilation which will change the air in the chlorine pit once every two minutes.

(g) Size of pool to warrant gas chlorinator - In general, pools of over 80,000 gallons capacity should be equipped with a gas chlorinator in preference to devices dispensing hypochlorite, if for no other reason than operational cost.

(2) Calcium and sodium hypochlorination

(a) General - These two forms of chlorine are manufactured by combining an alkali base with chlorine to form a hypochlorite.

(b) Strength of hypochlorite - Calcium hypochlorite which comes as a solid (powdered) material is available commercially in varying strengths of available chlorine from 70% on down. Sodium hypochlorite which comes in a liquid form is available commercially in varying strengths of available chlorine from about 4% to 12%.

(c) Methods of application

(I) Manual - Distribution by hand dosing is not desirable.

(II) Dissolving devices

(A) Dissolving baskets - Return water passing into the pool near a submerged basket filled with compressed hypochlorite tablets slowly dissolves the tablets and carries the active ingredients into solution.

(B) Dissolving cylinders - Controlled fresh water is passed through a cylinder containing hypochlorite tablets and the water carrying dissolved hypochlorite is carried into the pool. Control is developed by varying the volume of entering water.

(III) Reduced pressure or suction devices

(A) Pressure solution feeder ("Alum pot") - Heavy metal or plastic pots are connected to the water flow by small feed lines across an orifice plate installed in the main flow pipe. Needle valves in the inlet or outlet lines control the hypochlorite addition by varying the flow through the pot which is charged with a hypochlorite solution.

(B) "Siphon" feeder - This device depends on a reduced pressure created by passing a stream of water through a constriction to siphon hypochlorite into the water stream at the contriction.

(C) Air controlled suction feeder - A jar of liquid hypochlorite solution is directly connected into the suction side of the recirculatory pump, and flow is controlled by an air metering device which lets air into the jar to replace the solution which is withdrawn.

(IV) Positive displacement chemical feed pump- This diaphragm pump device is the preferred method of hypochlorination. It delivers a measured amount of hypochlorite through a two-valve pump chamber.

(3) Ammonia-chlorine disinfection

(a) General - Mixing of chlorine with anhydrous ammonia from gas cylinders or from ammonium sulfate produces a disinfecting compound known as chloramine which is more stable but has slower disinfecting power. It is not generally recommended for use in swimming pools.

(b) Methods of application - The same methods as used for gas chlorination or hypochlorination may be used.

b. Bromine disinfection

(1) General - Bromine is a member of the halogen family which is in a liquid state at room temperatures and has suitable properties for pool water disinfection.

(2) Methods of application

(a) Brominator - This device consists of a simple unit in which fresh or recirculated water is introduced into the bromine jar to form a solution which is conveyed into the pool.

(b) "Contact" pot - This is a pot filled with bromine liquid and placed in a closed pressure system on a by-pass line from the pump discharge. The water flows through the pot, picks up bromine and carries it into the pool.

(3) Construction safety precaution - Since bromine will burn on skin contact, it should be stored in recessed floor or wall-hung units to prevent accidental tipping of the bottles.

c. Other disinfection techniques

(1) Iodine - Iodine or iodine in combination with chlorine (as sodium or potassium iodide) are two techniques used for application of iodine to swimming pool waters.

(2) Ionized silver - This method of water disinfection is not generally considered practical for pool water.

(3) Ozone - The use of ozone for swimming pool water disinfection is not considered acceptable for pool waters because of the lack of lasting residual effect.

(4) Ultra-violet ray - This technique is not in general use for swimming pool disinfection.

9. Water temperature control devices

a. Pool water heating

(1) General - Most indoor and many outdoor pools are equipped with pool water heaters installed on a by-pass line on the discharge side of the

filtration system. In order to maintain a check on its efficiency of operation it is suggested that in-line thermometers be installed on the return and suction lines of the filtration equipment.

(2) Size requirement - A heater capacity of 7 to 10 BTU per hour per gallon of water recirculated is a standard often used.

b. Pool water cooling

(1) General - This is done as an aid to pool enjoyment during periods of prolonged hot weather. If the median water temperature can be cooled as little as 5°F, it may make an appreciable difference to the swimmer.

(2) Methods

(a) Aeration sprays - By-pass lines on return water inlets spray the return water up into the air before it reenters the pool.

(b) Aeration tower - Return water is pumped over a spray tower before it returns to the pool.

(c) Refrigeration - This method while expensive is the most efficient, in terms of speed and range of temperature drop.

Q. EQUIPMENT ROOM (see Figure 1)

1. Purpose - This room is designed to house the filtration equipment with the exception of the chlorination equipment and to provide space for operation and maintenance in an area not accessible to the pool patrons.

2. Construction Features

a. Ventilation - Adequate high and low ventilation by natural or artificial means should be provided here to remove excessive heat and air moisture.

b. Lighting - A mimimum light level of 10-foot candles on all working surfaces should be available both during day and night.

c. Room size - Sufficient head room must be provided to permit equipment maintenance. In addition, the area of the floor should be sufficient to provide for easy access to all sides of equipment and yet provide room for storage of chemicals and pool accessories such as pool vacuum equipment.

d. Floor - The floor should be of non-slip design graded to drain to floor drains at 1/4 inch per foot. A sump pit constructed under constantly dripping equipment (i. e., water lubricated pump) will reduce the flow of water on the floor.

e. Egress - This room should not open directly into the chlorine room but should be provided with some means of observing the operations in that room, such as through a non-movable glass panel of minimum size, 18 square inches. Dual egress should be provided here for safety reasons.

f. Location - Above ground locations are preferable to pit or subsurface installations from the standpoint of ease of maintenance and safety.

R. SWIMMER PREPARATION FACILITIES AND APPURTENANCES (See Figure 1)

1. General Location - The bathhouse should protect the pool area from prevailing winds and should be located to provide entrance to the pool area near the shallow end of the pool only.

2. Bathhouse Size - The bathhouse facilities including lobby, basket storage, dressing rooms and toilet facilities, as a rule, occupy an area about 1/3 that of the pool.

3. Dressing Rooms

a. Area provided - An area of 3.5 sq. feet for men and 7.0 sq. feet per woman should be provided. Since normal attendance at public pools is 2 men to each woman, equal areas can be provided. A general size for both dressing rooms is 1/5 the area of the pool.

b. Construction features

(1) Floors - Floors should be of smooth non-slip, impervious construction, constructed with a coved wall-floor joints and sloped to drains at 1/4 inch per foot. Applications of "granular-like" slip prevention coatings are desirable in areas where floors are continuously wetted.

(2) Dressing room booths and furnishings - These should be of simple design, constructed of impervious and smooth materials that will permit hose cleaning. Partitions in booths should terminate 6 inches above the floor.

(3) Hose bibs - Connections of 1-inch minimum size should be provided for area clean-up. Multiple bibs should be provided for ease in maintenance. Suitable hose racks (i. e. - 1/2 of an automobile wheel drum) will prevent accidental tripping over piled hoses.

(4) Ventilation - Natural and/or artificial ventilation will do much toward the maintenance of acceptable conditions in the dressing rooms. Roof construction with the central portion open as detailed in Figure 1, or open rafter gaps built into long roof overhangs are desirable features that pay off in operation.

(5) Heating- If the pool is used during the winter (such as with indoor pools), the dressing rooms must be provided with heating facilities that are capable of maintaining a constant temperature level of between 70° and 75° F.

(6) Lighting - A minimum lighting level of 10-foot candles at a point 3 feet from the floor should be available during both day and night.

4. Clothing Storage Area - When using bag-type storage,

an area of 0.75 sq. feet may be provided for each patron when a two-row high system is used. Additional area that will provide work aisles of 1 1/2 to 2 feet should also be included. If many of the pool patrons are children, wire basket type storage facilities will suffice, A combination of both types of storage facilities might prove valuable.

5. Sanitary Facilities

a. Shower areas

(1) Number of shower heads (based on maximum pool loading) - Showers should be provided for each 40 swimmers. In regimented situations, such as schools, the provision of one shower for every three members of the largest class will be ample. A water volume of 3 GPM per shower head is needed.

(2) Soap - Liquid soap is preferred because of the accident hazards involved in the use of bar soap.

(3) Water temperature control - A controlled water temperature of 90°F should be provided through a single, patron-operated valve. This water may be provided from a single source where the water mixing is regulated.

(4) Floors - The floor-wall joints in this area should be coved and the floor itself made of non-slip impervious material. The floor should slope to drain at 3/8 inch per foot.

b. Toilet facilities - (based on maximum pool loading)

(1) Commodes and urinals

(a) Men - One commode and one urinal should be provided for each 60 men.

(b) Women - One commode should be provided for each 40 women. Female urinals, if provided, may be used in the same proportion as for men in (1)(a) above.

(2) Lavatories - One lavatory with hot and cold water as well as soap should be provided for each 60 patrons. Circular foot-operated lavatories serving several persons at one time may be used for regimented situations such as schools.

(3) Construction - The same construction requirements as for shower areas apply here. In addition, permanent outside ventilation must be provided in commode areas.

S. FOOD SERVICE FACILITIES - The food service facilities must conform with structural regulations of the local community. Suggested regulations are contained in the Ordinance and Code Regulating Eating & Drinking Establishments, distributed by the Public Health Service.

REFERENCES

American Public Health Association; *Recommended Practice for Design, Equipment and Operation of Swimming Pools and Other Public Bathing Places*; American Public Health Association; New York, New York; 1957.

Hoffman-Harris, Inc.; *Take the Guesswork out of Pool Planning*; Hoffman-Harris; Inc.; New York, New York; 1957.

Meslin, J.; *Swimming Pool Operators' Text*; Florida Swimming Pool Operators' Association; Miami, Florida; 1957.

National Swimming Pool Institute Standards Committee; *Proposed Minimum Standards for Public Pools*; National Swimming Pool Institute; Harvard, Illinois; 1958.

Pearce, R. W.; "Principles of Chlorine Gas Feeders"; *Water and Sewage Works*; Vol. 101; No. 10; 1954.

Perkins, R. N.; *Operating Manual for Swimming Pools*; Refinite Company; Ralston, Nebraska; 1946.

Public Health Service; *Ordinance and Code Regulating Eating and Drinking Establishments*; Government Printing Office; Washington, D. C.; 1948.

State of Illinois Department of Health; *Sanitary Requirements for Swimming Pools*; State of Illinois; Springfield, Illinois; 1951.

The Refinite Company; *Modern Swimming Pool Data and Design*; The Refinite Company; Ralston, Nebraska; 1952.

Thomas, D. G.; *Pool Filtration and Chemistry*; Thomas Printing Company; Cleveland, Ohio; 1957.

AUDIO-VISUAL AIDS

1. CDC Slide Set (S142) - "Water, Sewage and Swimming Pool Graphics"
2. CDC Filmstrip (F133) - "Swimming Pool Sanitation"
3. CDC Filmstrip (F225) - "Operation of Hypochlorinators"
4. CDC Filmstrip (F146a) - "Functioning of Gas Feed Chlorinators, Part I"

5. CDC Filmstrip (F146b) - "Functioning of Gas Feed Chlorinators, Part II"

6. Filmstrip - "How and Why of Centrifugal Pumps"; Allis-Chalmers Manufacturing Co.; Milwaukee, Wisconsin

INSTRUCTION AIDS

1. Chemical samples - a. Alum; b. Diatomaceous Earth; c. Soda Ash; d. Calcium Hypochlorite; e. Lime

2. Samples of sand and anthrafilt filter media

3. Diatomaceous earth filter septum

4. Swimming pool fittings

    a. Adjustable face, return water inlet
    b. Main drain
    c. Vacuum connection
    d. Fill spout
    e. Skimmer
    f. Rate of flow indicator
    g. Alum pot
    h. Strainer
    i. Pool underwater light
    j. Sight glass
    k. Rate of flow controller
    l. Flo-jet return water inlet

5. Section of overflow gutter

6. Environmental Health Training Section posters -

    a. Typical plan of pool service facilities
    b. Longitudinal section through pool showing fittings
    c. Swimming pool piping system
    d. Swimming pool equipment room
    e. The diatomite filter
    f. Liquids sampling report
    g. Swimming pool inspection report
    h. Pool operator's weekly report
    i. Flow diagram - mechanical diaphragm, vacuum type chlorinator
    j. Flow diagram - visible vacuum chlorinator

    k. Flow diagram - solution feed chlorinator

7. Hypochlorinators
    a. Positive displacement pump
    b. Siphon feeder
    c. Dissolving basket
    d. Air controlled suction feeder

8. Sample of "granular-like" slip prevention coating

9. Samples of piping - (a) steel (b) plastic (c) copper

10. Brominator

11. Small laboratory type centrifugal pump

12. Pressure gauge

13. Vacuum gauge

Sample Calculations

MAXIMUM SWIMMER LOAD

PROBLEM:

Based on APHA criteria calculate the maximum number of persons which should be allowed in the swimming pool area. The pool has overall dimensions of 164' x 75' and is equipped with 2 diving boards which extend 10 feet over the water surface. 75% of the pool area has a depth of less than 5 feet.

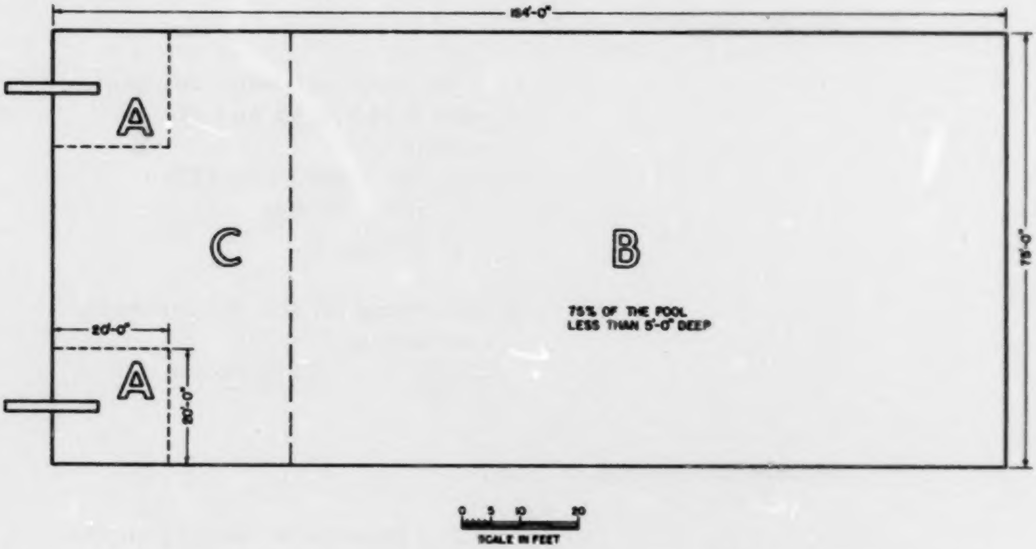


Figure 10 - Plan View of Swimmer Load Problem Pool

SOLUTION:

I. Total Pool Area = 75' x 164' = 12, 300 sq. ft.

II. Diving Areas A - 1. Two diving areas are provided. An area within 10' of each diving board is reserved for divers.

2. Diving Areas = 2(20 x 20) = 800 sq. ft.

3. Allowing 12 persons for each diving area we have 24 persons.

III. Non-swimming Area - B

1. 75% of the pool is of a depth less than 5 feet and can be considered for use by non-swimmers.
   .75 (12,300) = 9,225 sq. ft.

2. Allowing 10 sq. ft. per person-
   $$\frac{9225}{10} = \underline{923 \text{ persons}}$$

IV. Swimming Area - C

1. The area left after computing non-swimming and diving areas -
   = 12,300 - (800 + 9,225)
   = 12,300 - 10,025
   = 2,275 sq. ft.

2. Allowing 24 sq. ft. for each swimmer
   $$\frac{2275}{24} = \underline{95 \text{ persons}}$$

V. Maximum Swimmer Load

1. The maximum loading in the pool area equals the totals for Divers, Non-swimmers and Swimmers =
   24 + 923 + 95 = 1042 persons

Illustrative Problem

CALCULATIONS - REVIEW OF SWIMMING POOL PLANS

GIVEN: A swimming pool has the dimensions noted below (neglecting curvature of wall-floor joints). The basic equipment and fittings included with the pool are also noted below. The design head loss (resistance to flow through piping and equipment) may be assumed to be 50 feet for both filtering and backwashing cycles.

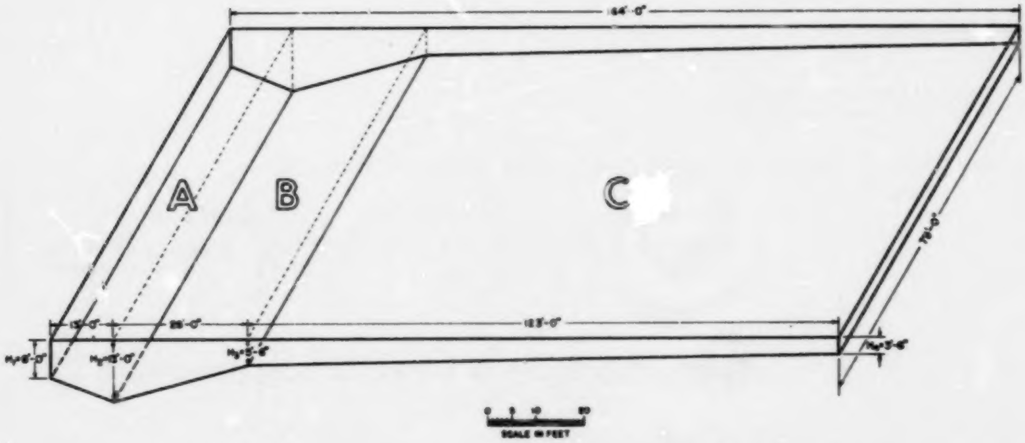


Figure 11 - Isometric View of Design Problem Pool

BASIC EQUIPMENT:

1. Filters - Five horizontal sand filter tanks, 8 feet in diameter and 14 feet long.

2. Pump - 40 H.P. double suction centrifugal pump rated at 50% efficiency under high load conditions.

3. Alum feeder - Dry feed machine with a maximum feeding capacity of 200#/24 hrs.

4. Soda ash feeder - Heavy duty diaphragm pump feeder with a maximum feeding capacity of 180#/24 hrs.

5. Chlorinator - Gas chlorinator with a maximum feeding capacity of 70#/24 hrs.

6. Main drains - 4 outlets spaced 15 feet on centers at deepest point; outlet pipes 8" diameter; gratings twenty-two inches square.

7. Return inlets - 30, 2" adjustable inlets on equal centers completely around the pool.

DETERMINE: The problem is to decide whether the basic equipment supplied is adequate for a 6-hour turnover (turnover ratio of 4).

SOLUTION:

I. VOLUME OF POOL

A. Pool Volume (cu. ft.)

$$= \text{Volume A} + \text{Volume B} + \text{Volume C}$$

$$= \left[\begin{matrix}\text{Surface}\\ \text{Area}\\ \text{A}\end{matrix} \times \frac{H_1+H_2}{2}\right] + \left[\begin{matrix}\text{Surface}\\ \text{Area}\\ \text{B}\end{matrix} \times \frac{H_2+H_3}{2}\right] + \left[\begin{matrix}\text{Surface}\\ \text{Area}\\ \text{C}\end{matrix} \times \frac{H_3+H_4}{2}\right]$$

$$= \left[(13 \times 75) \times \frac{8+13}{2}\right] + \left[(28 \times 75) \times \frac{13+5.5}{2}\right] + \left[(123 \times 75) \times \frac{5.5+3.5}{2}\right]$$

$$= \underline{\underline{71{,}175 \text{ cubic feet}}}$$

B. Pool Volume (gals.)

$$= \text{Cubic Feet} \times \text{Gallons per Cubic Foot}$$

$$= 71{,}175 \text{ (cu. ft.)} \times 7.48 \text{ (gals./cu. ft.)}$$

$$= \underline{\underline{532{,}389 \text{ gallons}}}$$

II. FILTER CHECK

A. Filtration Flow Rate (gals./min.)

$$= \frac{\text{Pool Volume (gals.)}}{\text{No. of Minutes in 6 Hours}}$$

$$= \frac{532,389 \text{ (gals.)}}{6 \text{(hrs.)} \times 60 \text{ (min./hr.)}}$$

$$= \underline{\underline{1479 \text{ gallons/minute}}}$$

B. FILTER AREA NEEDED

1. Calculation of Filter Area Needed (sq. ft.) $= \dfrac{\text{Filtration Flow Rate (gals./min.)}}{\text{Filtration Rate (gals./sq. ft./min.)}}$

$$= \frac{1479 \text{ (gals./min.)}}{3 \text{ (gals./sq. ft./min.)}}$$

$$= \underline{\underline{493 \text{ square feet}}}$$

2. Check of Filter Area Needed by Use of Nomograph (Swimming Pool Water Treatment Diagram, page 68) - By placing a ruler so that a straight line is formed from the 6 hour point on "Hours per turn-over" column to the 532,389 Gallons point on the "Pool Volume in Gallons" column, we may read both Filtration Flow Rate and Filter Area Needed. The results so obtained check with our calculated results.

C. CHECK WITH FILTER EQUIPMENT SUPPLIED - From Table III, "Filtration Area of Horizontal Pressure Sand Filters", page 70, we note that each horizontal filter has an area of 101 square feet. All five, therefore, have an area of 505 square feet. This exceeds our minimum area of 493 square feet and is therefore acceptable.

III. PUMP SIZE REQUIREMENTS

A. SIZE OF PUMP NEEDED FOR FILTERING

1. Pump Horsepower $= \dfrac{\text{Pumping Rate (gals./min.)} \times \text{Head(ft.)}}{3960 \times \text{Pump Efficiency (\%)}}$

$$= \frac{1479 \text{ (gals./min.)} \times 50 \text{(ft.)}}{3960 \ \frac{\text{(gals.-ft.)}}{\text{(min.-H.P.)}} \times 0.50}$$

$$= \underline{\underline{37.3 \text{ horse power}}}$$

B. SIZE OF PUMP NEEDED FOR BACKWASH

1. $$\begin{matrix}\text{Pumping Rate}\\ \text{for Backwash}\\ \text{(gals. /min.)}\end{matrix} = \left[\begin{matrix}\text{Area of}\\ \text{One Filter}\\ \text{(sq. ft.)}\end{matrix}\right] \times \left[\begin{matrix}\text{Backwash}\\ \text{Rate}\\ \text{(gals. /sq. ft. /min.)}\end{matrix}\right]$$

$$= 101 \text{ (sq. ft.)} \times 15 \text{ (gals. /sq. ft. /min.)}$$

$$= \underline{\underline{1515 \text{ gallons/minute}}}$$

2. $$\begin{matrix}\text{Pump}\\ \text{Horsepower}\\ \text{For}\\ \text{Backwash}\end{matrix} = \frac{\text{Pumping Rate (gals. /min.)} \times \text{Head (ft.)}}{3960 \times \text{Pump Efficiency (\%)}}$$

$$= \frac{1515 \text{ (gals. /min.)} \times 50 \text{(ft.)}}{3960 \left[\frac{\text{gals. -ft.}}{\text{min. -H. P.}}\right] \times .50}$$

$$= \underline{\underline{38.2 \text{ Horse Power}}}$$

It should be noted that one advantage of using five filters is that the backwash and filtration volumes are approximately the same. This is because the usual backwash volume is five times that of the filtration volume when one filter of the five is backwashed at a time.

C. CHECK WITH PUMP SUPPLIED - The 40 H.P. pump which is supplied exceeds the required size as calculated. The extra size provides a margin of safety for emergencies such as difficult backwashing due to encrustation of sand beds.

IV. CHEMICAL FEEDERS

A. ALUM FEEDER

1. $$\begin{matrix}\text{8 Hour}\\ \text{Feed Rate}\\ \text{Required}\\ \text{(\#/8 hrs.}\\ \text{feed period)}\end{matrix} = \text{Filter Area (sq. ft.)} \times \text{Alum Application Rate (\#/sq. ft. /8 hrs.)}$$

$$= 505 \text{ (sq. ft.)} \times 0.125 \text{ (\#/sq. ft. /8 hrs.)}$$

$$= \underline{\underline{63.1 \text{ pounds/8 hours}}}$$

2. $$\text{24 hr. Feed Rate Required (\#/24 hrs.)} = \text{Feed Rate (\#/8 hrs.)} \times \text{No. of 8 hr. Periods in a Day}$$

$$= 63.1\ \text{\#/8 hrs.} \times 3\text{(8 hr. periods)}$$

$$= \underline{\underline{\text{189.3 pounds/24 hours}}}$$

3. Check with Chemical Feeding Equipment Supplied - The alum feeder with a capacity of 200#/24 hrs. exceeds the calculated need of 189.3#/24 hrs.

B. SODA ASH FEEDER

1. Desired Size - The necessary feed rate of this device is difficult to predetermine because of the many variables involved. When using a gas chlorinator, however, it is desirable to have a feeder of similar capacity to the alum feeder.

2. Check with Equipment Supplied - The soda ash feeder with a capacity of 180#/24 hrs. is near enough to the range of the alum requirements to be considered acceptable.

C. CHLORINATOR

1. $$\text{Capacity Required (\#/24 hrs.)} = \frac{\text{Volume of Pool (gals.)}}{10{,}000 \left[\frac{\text{gals.}}{\text{\#/24 hrs.}}\right]}$$

$$= \frac{532{,}389\ \text{(gals.)}}{10{,}000 \left[\frac{\text{gals.}}{\text{\#/24 hrs.}}\right]}$$

$$= \underline{\underline{\text{53 pounds/24 hours (approx.)}}}$$

2. Check with Equipment Supplied - The chlorinator with a 70#/24 hrs. capacity exceeds the calculated need of 53#/24 hrs. This extra capacity might prove valuable in algae reduction by temporary super chlorination.

V. MAIN DRAINS

A. SIZE AND SPACING REQUIRES - Since the width of the pool exceeds 20 feet, multiple outlets must be provided. They must be no more than 20 feet on center and no closer than 10 feet to the side walls. The area of the outlet grating opening must be at least 4 times that of the discharge pipe.

B. CHECK WITH MAIN DRAINS SUPPLIED

1. Number Supplied - Four drains are supplied which meets the multiple drain specification.

2. Spacing - Drains are spaced 15 feet on center and 15 feet from the end walls and therefore also meet the spacing specification.

3. Area of Outlet Gratings

   a. Area of Opening of One Outlet Grating (sq. ft.) = Length (ft.) x Width (ft.) x % Open Area

   = 1.83(ft.) x 1.83(ft.) x 0.50

   = 1.68 square feet

   b. Area of one outlet drain (sq. ft.)

   $$= \frac{\pi \times (\text{Diameter in Feet})^2}{4}$$

   $$= \frac{\pi \times (.67\text{ft.})^2}{4}$$

   = 0.35 square feet

   c. Comparison of Areas

   4 x Area of One Outlet Drain (sq. ft.) = 4 x .35 (sq. ft.)

   = 1.40 square feet

   Since the area of each outlet grating opening is more than four times that of each outlet drain, the drains are acceptable in this category.

VI. INLETS

A. SIZE AND SPACING REQUIRED - For this large pool, inlets completely around the pool on no more than 20-foot centers, should be provided. The flow rates for 2" inlets should not exceed 50 gallons per minute.

B. CHECK WITH INLETS SUPPLIED

1. Spacing of Inlets (ft. /inlet)

$$\text{Spacing of Inlets (ft./inlet)} = \frac{\text{Perimeter of Pool (ft.)}}{\text{No. of Inlets}}$$

$$= \frac{478 \text{ (ft.)}}{30 \text{ (inlets)}}$$

$$= \underline{\underline{16 \text{ feet/inlet (approx.)}}}$$

Since the spacing is less than 20', this requirement is satisfactorily met.

2. Flow from Inlets (gals. /min. / inlet)

$$\text{Flow from Inlets (gals./min./inlet)} = \frac{\text{Filtration Flow Rate (gals./min.)}}{\text{No. of Inlets}}$$

$$= \frac{1479 \text{ (gals./min.)}}{30 \text{ (inlets)}}$$

$$= \underline{\underline{49.3 \text{ gallons/minute/inlet}}}$$

Since this flow is less than 50 gals. /min., this requirement is satisfactorily met.

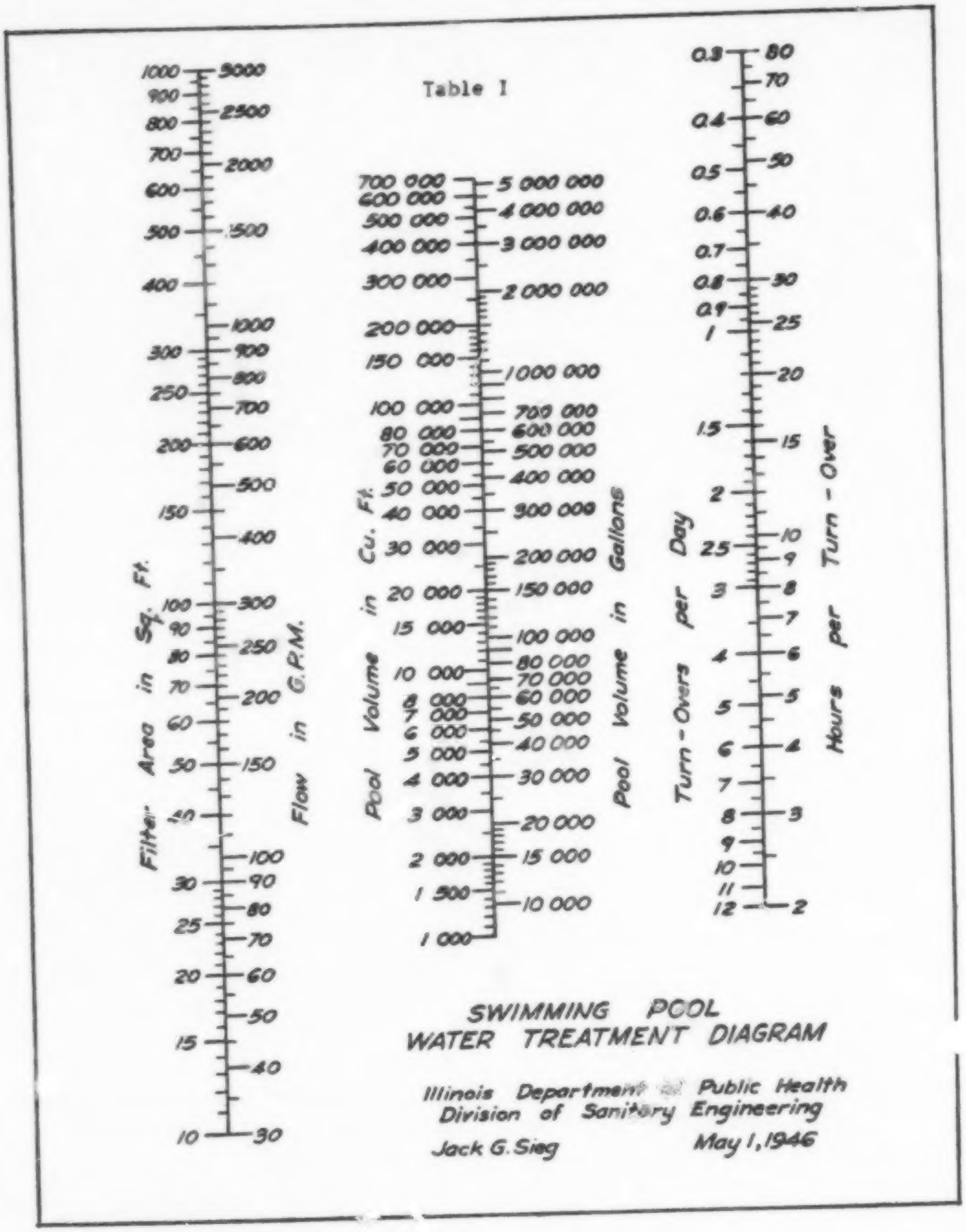
Note: On page 71, a "Check List of Sanitary and Public Health Items Related to Swimming Pools", is presented as a suggested aid to be used in the review of swimming pool plans.

Reprinted with Permission by the

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service

From Circular No. N822, State of Illinois Department of Public Health.

Table I



SWIMMING POOL
WATER TREATMENT DIAGRAM

Illinois Department of Public Health
Division of Sanitary Engineering
Jack G. Sieg May 1, 1946

Swimming Pool Water Treatment Diagram

TABLE II

FILTRATION AREA OF VERTICAL PRESSURE SAND FILTERS

TANK DIAMETER (Feet)	FILTRATION AREA (Square Feet)
2 1/2	4.91
2 3/4	5.93
3	7.07
3 1/4	8.30
3 1/2	9.62
3 3/4	11.04
4	12.57
4 1/4	14.19
4 1/2	15.90
4 3/4	17.72
5	19.63
5 1/4	21.65
5 1/2	23.76
5 3/4	25.97
6	28.27
6 1/4	30.68
6 1/2	33.18
6 3/4	35.78
7	38.48
7 1/4	41.28
7 1/2	44.18
7 3/4	47.17
8	50.27
8 1/4	53.46
8 1/2	56.75
8 3/4	60.13
9	63.62
9 1/4	67.20
9 1/2	70.88
9 3/4	74.66
10	78.54

TABLE III

FILTRATION AREA OF HORIZONTAL PRESSURE SAND FILTERS
(Filter Diameter — 8 Feet)

TANK LENGTH (Feet)	AVERAGE AREA (Square Feet)
10	71
12	86
14	101
16	114
18	130
20	145
22	160
24	175

The following check list is prepared as a suggested aid to be used in the review of swimming pool plans.

Check List

SANITARY AND PUBLIC HEALTH ITEMS RELATING TO SWIMMING POOLS

____________________________ Health Department

Pool Name ____________________________

Address ____________________________

[Check one - mark those items not applicable, N. A.]

	Completely Satisfactory	Not Completely Satisfactory
A. Pool Service Building (Dressing, toilet, storage, and other Service rooms)		
1. The pool building shields the pool area from the prevailing summer winds.		
2. The patron entrances and exits are located at the shallow end of the pool.		
3. The service building area is approximately 1/3 that of the pool area.		
4. Dressing rooms have an area approximately 1/5 that of the pool area.		
5. The clothing storage area is adequate for maximum pool attendance.		
6. Toilet rooms are located so that a person must pass through the shower area in going from the service building to the pool.		
7. Dressing room floor surfaces are smooth, impervious, non-slip, and pitch 1/4 inch per foot to drains.		
8. Toilet and shower room floors pitch 3/8 inch per foot to drains.		
9. Floor - wall joints are coved.		
10. Walls and partitions are smooth, impervious, and moisture resistant.		

	Completely Satisfactory	Not Completely Satisfactory
11. Bathhouses are separated by tight partitions when used simultaneously by both sexes.		
12. Booth partitions terminate at least 6 inches above the floor.		
13. Building facilities are naturally and/or artificially ventilated so that they will not remain excessively damp.		
14. Rooms are well lighted so that all parts are visible for cleaning.		
15. In indoor pools, the window or skylight area equals 1/2 the area of the pool, including runways.		
16. Indoor pools are provided with room heating facilities.		
17. Waste receptacles are provided in the pool building.		
18. Hose bibs of 1 inch minimum size are provided for clean-up.		
19. One lavatory is provided for each 60 patrons (at maximum attendance).		
20. Hot and cold water or tempered water is provided for the lavatories.		
21. One shower is provided for each 40 patrons (at maximum attendance).		
22. Pre-mixed, tempered water is provided for the showers.		
23. Showers are designed for a 3-gpm minimum flow.		
24. One toilet is provided for each 40 women patrons (at maximum attendance).		

	Completely Satisfactory	Not Completely Satisfactory
25. One toilet and one urinal is provided for each 60 male patrons (at maximum attendance).		
26. Food service facilities meet the local food service code.		

B. Construction Features of Pool and Pool Area (Exclusive of recirculation and disinfection equipment)

	Completely Satisfactory	Not Completely Satisfactory
1. The pool is located away from untreated roads, smoky industrial areas, and dusty playgrounds or parking lots.		
2. Grass, earth, or sand areas are excluded from the pool area. No overhanging foliage is present.		
3. Pool area is enclosed with 4-foot high fencing or dense shrubbery.		
4. Four-foot runways extend entirely around the pool.		
5. Runways slope at least 1/4 inch per foot away from the pool.		
6. Deck drains are provided for each 100 square feet of deck surface.		
7. Runway drainage is prevented from flushing back into the pool or from flooding neighboring areas.		
8. Life guard stands are provided for each 200 square feet of pool surface or fraction thereof.		
9. Hose connections of 1-inch minimum size are provided for pool area cleaning at intervals serving a 50-foot radius.		

	Completely Satisfactory	Not Completely Satisfactory
10. The area for spectators is separated from the swimmers' areas.		
11. Waste receptacles are provided in the pool area.		
12. Drinking fountains of approved design are provided in the pool area.		
13. The source of fresh water is approved.		
14. Water added to the pool from the supply source is through an atmospheric drop.		
15. Waste water is disposed of in an approved manner.		
16. Pool and pool area lighting are satisfactory and all wiring is of a safe design.		
17. A ladder or other means of egress is located at the deep end of the pool.		
18. A ladder or other means of egress is located at the shallow end of the pool if it is more than 2 feet from the runway to the bottom of the pool.		
19. A ladder or other means of egress is provided for each 75 feet of pool perimeter.		
20. Steps do not project into the pool.		
21. The heights of diving boards conform with maximum pool depths.		
22. Thirteen feet of free and unobstructed headroom is provided above the diving boards.		

	Completely Satisfactory	Not Completely Satisfactory
23. Increments of depth are shown on the sides of the pool in letters of 4-inch minimum height.	________	________
24. All internal surfaces are smooth and easily cleaned.	________	________
25. The pool lining is light colored.	________	________
26. The side and end walls of the pool are vertical for a depth of not less than 2 1/2 feet.	________	________
27. Junctions between the floor and walls are rounded.	________	________
28. 70%-80% of the pool area is of a depth less than 5 feet.	________	________
29. The slope of the pool bottom is not greater than 1 foot in 15 feet where the water depth is less than 5 1/2 feet for medium to large pools; and 1 foot in 8 feet for smaller pools.	________	________
30. There is no sudden change of bottom slope where the water depth is less than 5 1/2 feet.	________	________
31. At least one vacuum outlet is provided.	________	________
32. Inlets of proper number and location for recirculated water are provided to deliver uniform circulation.	________	________
33. Inlets discharge at a depth of 10 to 15 inches below the pool overflow level.	________	________
34. Inlets are of an adjustable type.	________	________
35. Multiple outlets are provided at proper locations where the pool width exceeds 20 feet.	________	________

	Completely Satisfactory	Not Completely Satisfactory
36. An outlet grating with openings four times the area of the discharge pipe is provided.		
37. Outlets of sufficient size to drain the pool in four hours are provided.		
38. Outlets from the pool are marked by dark colored circles or are easily visible.		
39. Overflow gutters extend completely around the pool.		
40. Overflow gutters have a minimum depth of 3 inches.		
41. Overflow gutter drainage outlets are placed at intervals of at least every 15 feet.		
42. Overflow gutter drain lines are at least 2 1/2 inches in diameter.		
43. Overflow gutter bottoms pitch 1/4 inch per foot to outlets.		
44. Skimming devices, at a ratio of one for every 800 square feet of pool area or fraction thereof, are provided.		
45. One skimmer is placed in the pool at a point opposite the direction of the prevailing summer winds.		
46. Skimmers are capable of handling 50% of the recirculated water.		
47. An equalizer line of 2-inch minimum size is provided on each skimmer.		
48. The wading pool is of the spray or fast-flow-through type.		

	Completely Satisfactory	Not Completely Satisfactory
C. Recirculation and Disinfection Areas		
1. Suitable general ventilation is provided for all areas.		
2. Artificial lighting is provided in all areas.		
3. Equipment and chlorinator rooms are provided with non-slip, impervious floors.		
4. Floors slope at the rate of 1/4 inch per foot to floor drains.		
5. A suitable means of automatically applying a disinfectant is provided.		
6. Chlorine tanks and the chlorinator are kept in a separate enclosure visible from outside of the enclosure.		
7. High and low ventilation is provided near the chlorinator.		
8. Pit installations of chlorinators are provided with automatic power ventilation.		
9. Chlorine tanks are provided with wall hung straps or floor recess areas to prevent accidental tipping.		
10. A pump and motor of sufficient capacity to deliver a 6 to 8 hour turnover is provided.		
11. The pool piping system is of sufficient size to provide a 6 to 8 hour turnover.		
12. A maximum rate of filtration of 2 to 3 gallons per square foot per minute is adhered to for filters.		

	Completely Satisfactory	Not Completely Satisfactory
13. A minimum backwash rate of 10 to 15 gallons per square foot per minute is adhered to for sand and anthrafilt filters.		
14. Air releases are provided at the highest point on each pressure filter.		
15. Pressure gages are installed on the influent and effluent lines of the filter system.		
16. A backwash sight glass is provided.		
17. Backwash water is disposed of through an air gap.		
18. Backwash water disposed of to a sewerage system passes through a sand trap before entering the sewer.		
19. A hair strainer of the proper design is provided.		
20. A coagulant feeder of the proper size is provided for sand and anthrafilt filters.		
21. A feeder for pH control substances of the proper size is provided.		
22. A diatomaceous earth precoat tank of the proper size is provided.		
23. A diatomaceous earth continuous feeder of the proper size is provided.		
24. A rate of flow indicator is provided.		
25. A rate of flow controller is provided.		

	Completely Satisfactory	Not Completely Satisfactory
26. A make-up tank of proper size and construction is provided.		
27. A pool water heater of proper size and construction is provided.		

D. Remarks on Items not Conforming

Section and Item No.	Remarks

Section and Item No.	Remarks

By____________________

Title____________________

Date Plans Received ____________________

Date Plans Reviewed ____________________

Lecture Outline

OPERATION AND MAINTENANCE OF A PUBLIC SWIMMING POOL AND BATHHOUSE

I. PATRON LOAD CONTROL

A. REASONS FOR MAINTAINING LIMITS

1. Sanitary Operation - The filtration, recirculation and disinfection equipment will only handle a reasonable limit of new foreign matter and microorganisms and still maintain good pool water conditions.

2. Safety - Overcrowding makes supervision of swimmers and sunbathers a difficult if not impossible task.

3. Enjoyment of Facilities - Loading of the pool area beyond reasonable limits will preclude the enjoyment of the facilities by anyone.

B. TECHNIQUES FOR SETTING PATRON LIMIT

1. General Limits

   a. Bacteriological results - Pool water sample results derived from samples taken under various loading conditions should be considered as an important guide line.

   b. Pool "design" loading - The pool has a design capacity (see lecture outline - "Constructing and Remodeling a Public Swimming Pool and Bathhouse", Section II B-2 page 16), based on surface area which should be considered in setting up a patron limit, under one of the techniques described below.

2. Specific Formulae

   a. Fill and draw pools

      (1) Without disinfection - the loading should not exceed one patron for each 500 gallons of water in the pool between complete changes of pool water.

      (2) With intermitent disinfection - The limit set out

in 1-b above should prevail.

b. Flow through pools

(1) Basic method - The loading should not exceed one patron for each 500 gallons of water added to the pool.

(2) Becker's formula

$$Q = 6.25\ T^2$$

where

Q = Quantity of fresh water added per patron

T = Replacement period for the pool volume, expressed in hours

c. Recirculatory pools with continuous disinfection

(1) Mallmann's formula - A maximum patron load of one patron per 35 to 45 square feet of pool area is indicated by this investigator.

(2) Becker's formula

$$L = \frac{3.84\ C}{T^3}$$

where

L = Maximum daily patron load

C = Capacity of pool in gallons

T = Replacement or turnover period for the pool volume, expressed in hours.

(3) Basic method - The number of patrons in one turnover period (6 to 8 hours, if properly designed) should not exceed one per fifty gallons of pool capacity.

II. THE MAINTENANCE OF THE PROPER DISINFECTANT AND pH LEVEL IN POOL WATER

A. CHLORINE RESIDUAL

1. Test Procedure - The proper testing procedures for determination of free chlorine residual are given on page 117, in the lecture outline, "Testing Swimming Pool Water for Chlorine Residual and pH."

2. Free Chlorine Residual vs. Combined Available Chlorine Residual

   a. Combined available chlorine residual - The addition of anhydrous ammonia to pool water in combination with chlorine or the reaction of organic matter in the pool water with chlorine will form disinfecting compounds known as chloramines. These compounds are much less active than free chlorine in the rapid destruction of microorganisms. While these slower acting disinfectants seem to be longer lived than free chlorine, the slowness of their action dictates that they are not as valuable in swimming pool disinfection. (To obtain 100% bacterial kill using the same amount of residual chloramine and free chlorine, requires approximately 100 times the contact period for chloramine.)

      While not recommended, if chlorine-ammonia disinfection is practiced, a residual of 2.0 ppm combined chlorine residual should be maintained.

   b. Free chlorine residual - The level of chlorine residual in pool waters at all times should be between 0.4 and 1.0 ppm free residual. A recent development in this country has been the maintenance of higher free residual chlorine concentrations with accompanying high alkalinity (1.0 ppm and above free residual chlorine and pH levels of 8.0 to 8.9).

B. BROMINE RESIDUAL

1. Test Procedure - The chlorine test kit can also be used to test for bromine residuals. Readings derived from the chlorine standards using brominated water are doubled

to arrive at the corrected reading (i. e., if the test results indicate 0.3 ppm, the correct reading is 0.3 x 2 = 0.6 ppm bromine).

2. Bromine Residual Level - Operators should maintain a bromine residual of 1.0 ppm or above. These high bromine levels do not ordinarily cause eye or skin irritation.

C. pH LEVEL

1. Test Procedure - The proper testing procedures for determination of pH level are given on page 120 in the lecture outline, "Testing Swimming Pool Water for Chlorine Residual and pH."

2. Importance of Proper pH Level

   a. Coagulation - When using sand filters equipped for the addition of coagulant chemicals, pH is an important factor in the proper production of a "floc". The optimum point for alum flocculation is about 7.2 to 7.6 depending upon the hardness and total alkalinity of the water.

   b. Disinfection - If the pH becomes too high the effectiveness of chlorine disinfection is greatly reduced.

   c. Swimmer comfort - pH levels below 7 or above about 8.4 may result in skin and eye irritation to the swimmer.

   d. Algae production - At reactions below a pH of 8.1 most water contains free carbon dioxide necessary for the growth of algae. Waters with a pH above this point are likely to have less algae troubles.

3. Optimum pH Level - In any case the pH of pool water should be above 7.0. A balancing of the advantages and disadvantages involved dictate an optimum level of 7.5 to 8.0.

4. Factors Affecting pH Level

   a. Disinfectants

(1) Chlorine gas and pure bromine - These compounds lower the pH.

(2) Hypochlorites - These compounds raise the pH.

b. Coagulants - Alum, the most commonly used coagulant, lowers the pH.

c. Fresh water - The make-up water added to the pool can cause a considerable change in pool water pH if it is high in alkalinity or acidity.

5. Control of pH - The operation and maintenance of devices for dispensing control chemicals is discussed in Section III E of this outline. The chemicals fed are noted below.

a. pH raising compounds

(1) Soda ash (sodium carbonate) - This compound will raise a depressed pH and may be fed through a feeding device or be placed in briquet form near a recirculation outlet of the pool. In the latter technique, the briquet is slowly dissolved by water movement.

(2) Caustic soda (sodium hydroxide or lye) - This compound is more hazardous to use but has more effect in raising pH, pound for pound, than soda ash.

(3) Lime (calcium hydroxide) - Lime will raise pH, but is not recommended for use at pools because it may result in turbidity in pool water and possibly lead to cementation of the filter sand.

b. pH lowering compounds

(1) Dilute hydrochloric or sulphuric acid - The use of this compound is a hazardous procedure from the standpoint of injury to the operator, the swimmer, and the equipment. Furthermore, it may disturb alum coagulation and increase turbidity.

(2) Sodium bisulfate (sodium acid sulfate) - This compound is safer to use than the mineral acids and has the additional benefit of removing lime

deposits from chemical feed lines, filter sand, and piping.

III. OPERATION AND MAINTENANCE OF POOL RECIRCULATION AND DISINFECTION EQUIPMENT

A. HAIR STRAINER

1. Opening for Inspection - This device should be opened at least weekly for inspection. Bolt type fastening devices should be replaced with a single screw clamp such that the device will more likely be opened at frequent intervals.

2. Strainer Baskets - Two of these should be available such that a basket can be dryed before cleaning with a stiff wire brush.

3. Emergency Use - This device can be used to add chemicals, such as disinfectants, coagulants, algicides and pH control compounds,into the pool water in the event of normal dispensing equipment breakdown.

B. MAKE-UP TANK

1. Cross Connections - If the fresh water supply enters below the maximum overflow level of the tank, this entrance pipe should be raised to provide an air gap entrance. For delivery pipes entering over the tank rim, a temporary correction may be made by boring a 1/8 inch hole into the pipe bottom at the point where the pipe crosses the tank water surface before dropping down into the tank proper.

2. Use as Balance Tank - If the tank is elevated to a point where its maximum water level is the same as that in the pool proper, it can be used to maintain the pool water surface just at the rim of the overflow gutters.

3. Emergency Use - This device can be used to add chemicals, such as disinfectants, coagulants, algicides and pH control compounds into the pool water.

C. PUMPS AND MOTORS

1. Protection Against Corrosion

   a. Oxidation - The pump and particularly the motor should be protected against excessive pooled or splashed water or sanitary chemicals. Proper floor draining and room ventilation will do much toward this end.

b. Galvanic - Pumps made of dissimilar metals may be subject to galvanic corrosion. Difficulties due to corrosion can be minimized by using an anodic metal such as cast iron for the pump housing and a cathotic metal such as bronze for the impeller. This will help protect the more important impeller and distribute the corrosion over the large pump housing area.

2. Pump Operation

a. Pump-packing glands - Packing glands in many centrifugal pumps are lubricated by a controlled leakage. Several drops per minute will usually suffice. The adjustment of the stuffing box gland nut will provide this required leakage.

b. Priming - Air which will prevent successful operation is excluded by priming. This must be done with the pump not running to prevent damage to the water lubricated packing rings.

c. Lubrication - Manufacturer's instructions should be followed in providing lubrication for the ball bearings on the pump and motor. "Lime-soap" grease is an often recommended lubricant. Over lubrication can result in heat damage to bearing surfaces.

d. Operation difficulties

(1) Failure to pump - This may be caused by lack of priming, wrong direction of impeller rotation or too low a motor speed.

(2) Reduced pumping capacity - This may be caused by air pockets or leaks in the suction line, a clogged impeller, an excessively worn impeller, or a total head loss in excess of that recommended for the pump.

(3) Pump losing prime - This may be caused by air leaks in the suction line, excessive air carried to

the pump with the pool water, or air entering the line through the stuffing box.

(4) Mechanical troubles and noise - This may be caused by misalignment of the motor-pump shaft, a bent shaft, damaged bearings, or an improperly proportioned suction and discharge line combination.

D. DISINFECTION EQUIPMENT

1. Hypochlorination

a. Making stock solutions

(1) Quantity used - Stock solutions can be made by mixing sodium or calcium hypochlorite into water. The following table gives quantities for preparing solutions.

TABLE IV

Quantities of Hypochlorite Needed for Preparing 10 Gallons of 1% Solution (10,000 ppm)

% Available Chlorine	Quantity Used
5.0	8 qts. Sodium Hypochloride
15.0	5 1/2 lbs. Calcium Hypochloride
70.0	19 oz. Calcium Hypochloride

(2) Mixing precautions

(a) Elimination of sediment

(1) Pre-settling - To prevent clogging of the feeding devices' small parts, hypochlorite solutions should be premixed in a suitable crock and the excess carrier allowed to precipitate. The supernatant can then be siphoned off and used in the feeding device.

(II) Water additives - When hard water is used for mixing the hypochlorite solution, sodium hexametaphosphate or tetra sodium pypophosphate may be added to prevent excessive sediment production. These compounds may be mixed in the ratio of 1 to 1 1/2 ounces per 100 gallons, for each grain (17.1 ppm) of hardness.

b. Maintaining the working parts of hypochlorinators

(1) Cleaning

(a) Daily cleaning - Flushing all parts with clear water will do much toward maintaining the parts in operating condition. The strainer connection on the suction side of the hypochlorinator must be brush cleaned daily to prevent clogging of the intake orifices.

(b) Semi-monthly cleaning - Treatment of the valves and other important parts of the hypochlorinator with acid solutions will be necessary to remove chemical deposits. This is particularly true with pool waters that are high in carbonates, sulfates and iron. Dilute muriatic (hydrochloric) acid, dilute acetic acid or undiluted vinegar may be used for the cleaning solution. Brushing with a stiff bristle brush will facilitate cleaning.

(c) When to make stock solutions - When exposed to light, and at room temperature, prepared liquid solutions will loose up to 7% of their active strength during a 14 day storage period.

(2) Replacement parts - Each pool operator should maintain a supply of replacement parts such as valves, valve seats, diaphrams and connective hose, in order that long delays in operation will not be necessitated by equipment failure. Many hypochlorinator manufacturers will provide part kits as a packaged unit.

c. Operating difficulties

(1) Clogged lines - The most common cause of operating

difficulty is clogged lines due to chemical deposits. Preventitive maintenance cleaning will preclude this difficulty.

(2) Interruption of solution discharge

(a) Suction line trouble - Priming of the suction line is frequently necessary in order to exclude air and permit solution pickup.

(b) Discharge line trouble - If the line pressure into which the chlorine solution is being discharged exceeds the capacity of the hypochlorinator, no solution will be delivered. This can often be remedied by changing the point of chlorine application such as injecting chlorine on the suction side of pump in place of the discharge side.

(3) Uncontrolled change in feed rate - Changes in discharge line back pressure, caused by changes in hydraulic conditions in the system and hypochlorinator water supply pressure are but two things which can change the quantity of chlorine being fed into the system. The use of regulating devices such as rate of flow controllers and pressure regulating valves will help to minimize this difficulty. The basic limitations of a hypochlorinator can not be overlooked in any event.

2. Chlorination

a. Handling chlorine containers

(1) Storage

(a) Safety plugs - Since these containers have fusible plugs which will melt at 160°F., they should be stored under cover, in areas away from excessive heat (such as pool water heaters).

(b) Below ground storage - Since chlorine gas is heavier than air a leaking container could create a hazardous condition in unventilated storage areas beneath ground level.

(c) Tank in use - The chlorine tank or cylinder in use must be firmly held in a recessed sump, wall hung strap, or similar device to preclude its being knocked over and releasing chlorine gas.

(2) Transporting cylinders - Cylinders should never be moved unless the protective cap is in place.

b. Connections from cylinder to chlorinator

(1) Temperature considerations - The temperature of the chlorine cylinder should not be higher than the chlorine feed lines in order to prevent formation of chlorine hydrate and subsequent line clogging. In cooler weather the chlorine line and chlorinator may be heated by a suspended light bulb or electric heating device on the supply line. In no case should supply lines be run along cold walls or exterior windows.

(2) Pipe fittings and connections - New gaskets (usually soft metal) should be used on all connections. Leaks may be prevented by using a paste of litharge and glycerine at joints after cleaning.

(3) Chlorine gas shutoff - Gas can be delivered to or shut down from the auxillary control valve (which is fitted on each newly used tank) by making one complete counter clockwise turn on the cylinder valve. Leaks at this valve can be corrected by tightening the packing nut at the valve stem.

c. Leak detection

(1) Ammonia - A small piece of cloth soaked with ammonia and wrapped around the end of a short stick can be used to detect leaks. If chlorine gas leakage is occurring, a white cloud of ammonium chloride will form.

(2) Special leak detectors - Special plastic squeeze bottles are available which can be used to shoot a stream of detection fluid on a suspected leaking area. A mass of live bubbles is produced at any point of chlorine leakage and as these bubbles

burst, puffs of "smoke" are released.

d. Ventilation - High and low ventilation should be supplied for chlorine rooms. Below ground or pit installations should be replaced or equipped with automatic ventilation as described in the outline "Construction and Remodeling a Public Swimming Pool and Bathhouse."

e. Determining when a cylinder is nearly empty

   (1) Weight - 100-pound cylinders weigh 193 pounds when full (cylinder weight - 93 pounds) and 150-pound cylinders weigh 273 pounds when full (cylinder weight - 123 pounds).

   (2) Gas pressure - The gas pressure gauge will show a marked drop, when a cylinder is almost empty. (If a nearly empty cylinder is connected in parallel with a full one the rate of withdrawal will be equal in both containers).

   (3) Observing the chlorinator - Visible vacuum type chlorinators (Bell Jar installations) will begin to bubble in air and other chlorinators will show erratic movements of rotometer dose indicators.

f. Gas masks - Gas masks should be provided at a point accessible to the operator in the event of an emergency.

   (1) Type - Type N canister masks (U.S. Bureau of Mines) equipped with a chlorine type canister may be used with low concentrations of chlorine in air.

   (2) Limitations

      (a) Life - The type N mask has a useful life of only from 2 to 6 hours.

      (b) Strength of gas - The type N mask will protect only against concentration of chlorine in air of from 1% to 2% by volume.

      (c) Oxygen depletion - The type N mask will give no protection in areas deficient in oxygen.

(3) Maintenance of canisters - Canisters should be replaced (even if they are not exhausted) in the event that either of the canisters seals have been broken or if they have been stored at the pool site for over three years.

g. Emergencies

(1) Blown safety plugs - Put the cylinder in a tank of caustic soda or soda ash (300 pounds of soda ash in 100 gallons of water for a full 100 pound cylinder) solution or run a hose from the plug opening to the caustic solution.

(2) Human exposure - If a person has been exposed to the gas, remove him to fresh air, call a doctor, and keep the patient warm. To relieve nose and lung irritation have the person inhale fumes from a pan of steaming water to which has been added a small amount of a mentholated ointment used for head colds, or one teaspoon of tincture of benzoin. If the patient stops breathing, administer artificial respiration.

E. COAGULANT FEEDING EQUIPMENT

1. Principles of Coagulation - When alum is mixed with pool water on the suction side of the recirculation pump, it precipitates in the form of a white gelatinous snowflake. This precipitate will catch on the surface of sand filter forming a gelatinous mat. This mat will catch and hold fine particles of turbidity that ordinarily might pass through the filter.

2. Use of Coagulants - Coagulants, principally alum, are used with sand and anthrafilt filters of the pressure and gravity types.

3. Types of Alum

a. Aluminum sulfate - This is the most commonly used coagulant. When fed through pressure solution feeders, it may form a pasty mass and impede uniform feeding.

b. Ammonium aluminum sulfate (ammonium alum) - This compound has better feeding characteristics than aluminum sulfate but its continual use adds ammonia to the water. This causes the formation of chloramines, when chlorine is used as the disinfectant.

c. Potassium aluminum sulfate (potassium alum) - This compound normally has only approximately 60% of the floc producing capacity of aluminum sulfate.

d. "Special" filter alums - Some special formulations are compounded by various manufacturers and marketed under such trade names as "Floc-Aid" and "Catalyzer". These compounds are generally more expensive than plain aluminum sulfate but have special advantageous properties.

4. Feeding Techniques

a. Place of addition - Alum should be added on the suction line of the recirculating pump. This allows for additional mixing by passing through the pump and permits a longer reaction time before reaching the filter surface.

b. Time of addition - The alum should be added to the pool water immediately after backwashing, in a 6 to 8 hour time interval.

5. Quantity of Coagulant Fed - As a rule of thumb, a quantity of alum equal to 2 ounces of alum per square feet of filter area, should be fed over the prescribed time period. The exact or optimum feeding rate may be set by making a jar test.

Pools supplied with water of low total alkalinity, may cut the alum dose considerably if water of zero turbidity can be produced with lower doses.

6. Operational Problems

a. Overfeeding - This may shorten filter runs by clogging the filter surface.

b. Underfeeding - Fine turbid matter may pass back into the pool because of this.

c. Production of a cloud of "floc" in the pool - This may be caused by too short an alum reaction time and passage of alum through the filter which will react in the pool itself. This may also happen if the pool water is very low in alkalinity naturally or if the pH of the pool water is allowed to drop below the neutral point. (By the effects of gas chlorination, as an example.)

d. Clogged feeding devices - Cementation of alum feeders is a common problem that can be prevented in part by thorough flushing of the device and feed lines. This should be done each time the proper quantity of coagulant has been added after backwashing.

Plugged lines may be cleaned by application of a caustic substance such as lye. In many cases, replacement with new lines becomes cheaper in the long run.

F. pH CONTROL FEEDING EQUIPMENT

1. Operation - These devices feed control chemicals previously described, in order to maintain optimum pH conditions.

2. Operational Problems

a. Partial loss of "floc" mat - After batch dosing with soda ash it is possible that a part of the sand filter mat may dissolve and carry turbidity into the pool. This, of course, is not a problem with diatomaceous earth filters. It may be prevented by either continuous maintenance of pH level by slow feeding techniques or by adding batch doses of soda ash or other control substances after backwashing, before beginning the alum feed.

b. Creation of a precipitate in the pool - Soda ash when thrown into the pool in powdered form can cause a precipitation of hardness compounds. This can be prevented by feeding ahead of the filters in the normally prescribed manner.

c. Feeder maintenance - In general, the same maintenance and cleaning procedures applied to hypochlorinators will be effective with these devices.

G. FILTER AID (DIATOMACEOUS EARTH) FEEDING EQUIPMENT

1. **Precoat Feeder**

a. Quantity fed - A 1/10 to 1/32 of an inch depth of diatomaceous earth is fed onto the filter septa by delivering about 0.125 pounds per square foot of filter surface. This may be fed onto the filter by recirculation for about five minutes.

b. Operational problems - Difficulties of impacted filter feed lines may be avoided by flushing the feeding device with pool water after precoating.

2. Body Feeder

a. Quantity fed - To build up a continuous layer of filtering media, a continuous feed of diatomaceous earth should be delivered into the water during the filter run at the rate of about 1 1/2 parts for each part of water turbidity. In general, this will amount to about 1 to 4 ounces per 1000 gallons recirculated per day.

b. Operational problems

(1) Compaction - The compaction of the filter aid material often results in malfunctioning of the feeding device. The addition of a constant mixing device such as mechanical stirring or air agitation will eliminate much of this difficulty.

(2) Clogged feed lines and dispensing parts - If the feeding device is flushed with pool water (without the addition of diatomaceous earth) before it is shut down for any interval of time, this difficulty may be minimized.

H. FILTRATION EQUIPMENT

1. Gravity Sand Filters - The installation of this type of filter for swimming pools is no longer common practice. The basic principles of operation and maintenance are similar to those discussed under pressure sand filters.

2. Pressure Sand Filters

a. Operation - These filters are supplied with a filtering mat of coagulant material and operated 24 hours a day at 3 (or 2) gallons per square foot per minute until the difference in pressure between the influent pressure gauge and the effluent pressure gauge is in the range of 5 to 7 pounds per square inch. They should then be backwashed at the rate of 15 gallons per square foot per minute (8 gallon per square foot per minute for anthrafilt media filters) for about five minutes or until the backwash water appears clear for 2 minutes.

b. Operational problems

(1) Air binding - Short circuiting of the filter inflow can be caused by air trapped in the top of the filter. An air release valve located in the top of the shell will release this air. Automatic or manual valves are available. When painting the filter unit, do not paint the automatic valve shut.

(2) Mechanical loss of filtering mat - Shutting down for extended periods of time, such as during the night will not only preclude good operation based on filter design but will result in a partial loss of the uniform filter mat.

(3) Inability to read pressure differential - High reading gauges should be replaced with those that read in the range of the filter's operation. In general, gauges reading up to only 30 pounds per square inch are desirable.

Another operational difficulty may be avoided by mounting gauges on the tops of filter lines to preclude clogging with sediment.

(4) Rate of flow change through filters - With the pump running at the same speed, different amounts of water will pass through the filter throughout a filter run. In order to deliver a continuous 3 (or 2) gallons per square foot per minute through the filter, a rate of flow controller can be installed.

(5) Filter media difficulties - Filters that are failing to produce a clear effluent should be inspected by removing the manhole cover and inspecting the sand surface after backwashing.

(a) Clean sand surface - This would indicate satisfactory operation.

(b) Dirty sand surface - This would indicate unsatisfactory conditions. The filter should be backwashed slowly and the rising water observed.

(I) Water "breaks" evenly during test backwash - More water is needed for backwashing in this case. While the trouble may lie in an inadequate backwash pump capacity, temporary relief may be obtained by removing the top layer of sand and washing it in a lye (caustic) solution.

Another technique is to give the whole sand bed a "caustic bath" by applying 1 pound of lye per square foot of filter surface after allowing the water to drain down to within two inches of the sand bed surface. After four to six hours of soaking, the filter may be drained and then thoroughly backwashed.

(II) Water "breaks" unevenly during test backwash - This would indicate obstructions in the filter bed or underdrains.

This might be caused by "mudballs" or accumulations of dirt and sand held together by organic growths. This sometimes can be corrected by applying 2 ounces of calcium hypochlorite per square feet of filter surface and practicing a soaking operation as described above. Maintenance of adequate backwash rates and application of pool disinfectant chemicals ahead of the filters will probably prevent this difficulty from reoccurring.

Some success has been reported with the use of an "acid bath" for correction of clogged filters and underdrains. 2 pounds of sodium bisulfate per square foot of filter area is added and then filters permitted to soak as described above. Thorough backwashing is critical after this type of treatment to prevent damage to the metal parts of the system.

Cementation of sand grains due to mineral compounds normally in the water or added in water treatment may preclude correction by these treatments, in which case the sand might have to be replaced.

Sodium hexametaphosphate may be fed into water to prevent the undesirable effects of excessive hardness. Dosing in the range of 5 ppm is generally accepted. One suggested technique for batch feeding is to add ten pounds of the compound for each 250,000 gallons of pool capacity at the start and two pounds for each 250,000 gallons every other week.

3. Diatomaceous Earth Filters

a. Operation - These filters are equipped with various types of filtering surfaces which are covered with diatomaceous earth prior to their being put into service. They are generally operated at 2 to 3 gallons per square feet per minute and operated 24 hours a day.

Pressure filters are backwashed when the influent and effluent pressure differential is in the range of 25 to 50 pounds per square inch, depending on the type used. Vacuum filters are backwashed at a vacuum gauge reading of about 10 to 15 inches of mercury.

b. Operational problems

(1) Short filter runs - While a shorter filter run than obtained with a sand filter is expected with this type of filter, extended hours of use can be obtained by careful attention to the application of body feed throughout the operation of the filter cycle.

(2) Clogged filter elements or septa - Elements made of metalic material or synthetic fiber "cloth", may be freed from encrusted debris by one of the following treatments:

(a) Diatomite and organic matter clogging - This may be removed by soaking the elements in an 8% solution of sodium hexametaphosphate (one commercial compound containing this is Calgon) for two hours and then scrubbing them with a wire brush.

(b) Iron clogging (rust colored deposit) - This may be removed by soaking in hydrochloric (muriatic) acid.

(c) Manganese clogging (gun metal deposits) - This may be cleaned by soaking in a solution of hydrochloric acid to which a small amount of sodium sulphite has been added.

(d) Calcium and magnesium deposits - Water hardness chemicals can be removed from the elements by the application of hydrochloric acid as noted in (b) above.

(3) Loss of filter cake - Shutting down the filtration operations for even a short period of time will result in "sluffing" of the filter cake of diatomacious earth. If the filter is shut down for any reason, it should be backwashed and a new precoat added.

(4) Failure of filter elements - Early filter elements were subject to excessive operational breakage. Newer elements, and different filtering procedures have largely overcome these difficulties.

I. POOL HEATERS

1. Intermittent Operation - In cool weather when the pool heater is first put into operation, it is best not to turn the heater off and on intermittently. Best results will be obtained by setting the thermostat to prevent the pool water temperature from dropping below 65°F. This will permit raising pool temperature to a comfortable swimming temperature in a shorter time.

2. De-scaling the unit - The unit can be de-scaled by flushing it with a 50-50 mixture of hydrochloric (muriatic) acid and water until the chemical foaming action stops. The flushing can be facilitated by shutting off the inlet and

outlet water lines, opening the heater drain and pouring the acid mixture in through a high standpipe installed on the discharge line. Displaced air may be vented out through another standpipe installed on the inlet line.

IV. ALGAE CONTROL

A. GENERAL - These plant forms are brought into the pool by the wind and with fresh make-up water. If uncontrolled,they will grow abundantly in the presence of sunlight. They are found in the free floating and clinging varieties. The clinging type will embed itself into pores and crevices in concrete and is a more persistent type to treat.

B. OBJECTIONAL FEATURES OF ALGAE

1. Chlorine Demand - Since they are organic in nature they will create a high chlorine demand and once they have obtained a "toe hold" in the pool, the maintenance of a chlorine residual is difficult.

2. Water Turbidity - The increased turbidity in the pool due to algae is not only esthetically objectionable but creates a hazard to proper swimmer supervision.

3. Slipping - Algae growths create an additional hazard in that they may increase pool accidents due to slipping on pool bottoms, sides, walkways and ladders.

4. Effect on Bacterial Growth - In addition to buffering bacteria from the effects of chlorine by creating a high chlorine demand themselves, algae also may actually foster bacterial growth.

5. Odor - Algae create odor problems particularly when reacting with chlorine.

C. DETECTING ALGAE GROWTH EARLY - Algae being a plant, requires carbon dioxide in order to manufacture food. In the process of taking carbon dioxide out of water, there is a definite increase in the pH. This may be seen in a radical jump in pH (from 7.5 to 8.0 as an example) in several hours, before there is any noticeable growth in the water.

D. METHODS OF CONTROL

1. Routine Chlorination - The maintenance of a free chlorine residual in the pool at all times will prevent the start of algae troubles.

2. Pool Shading - Since algae need sunlight for growth, the shading of the pool with a car-porte like device will prevent growth.

3. Temperature - When the pool water is at a temperature of less than 80°F., the algae problem is minimized.

4. Application of Copper Sulfate to the Pool Water

   a. Shock treatment - A treatment dose of 10 pounds per million gallons of pool water can be introduced by putting crystals of copper sulfate into a porous bag and moving it through the pool water.

   b. Maintenance dosing - Pools that experience continuous algae difficulties due to some uncontrollable factor may practice preventive application of copper sulfate. This may be done by introducing an initial dose of 0.5 ppm and maintaining a 0.3 to 0.5 ppm level by dosing every 5 to 7 days.

   c. Difficulties involved in the use of copper sulfate

      (1) Effect of hard water - The effective portion of the copper compound is precipitated by alkaline carbonate and rendered ineffective.

      (2) Effect on swimmers - The compound may discolor swimmers suits and hair.

      (3) Production of an inky precipitate - When hydrogen sulphide is present in the water it will cause an inky precipitate of copper sulphide.

5. Application of Quaternary Ammonium Compounds - These compounds are not intended to supplant the use of a disinfecting agent but will permit the disinfectant to have greater effect in attacking algae, because of the lowered surface tension of the pool water.

   The usual dose is 1 gallon per 50,000 gallons of water initially and subsequent dosages of 1 quart per 50,000 gallons every 6 days.

6. Superchlorination - One of the most effective treatments is the development of a 10 ppm free chlorine residual in the pool during non-swimming hours.

   Excessively high residuals may be reduced to permit swimming, by adding sodium thiosulfate to the water at the rate of 1.0 to 1.5 ppm for each 1.0 ppm of residual chlorine being removed.

7. Pool Scrubbing - As a last resort the pool may be drained and the bottom and sides scrubbed with a 5% hypochlorite slurry or copper sulfate solution to remove tenaceous algae growths.

8. Pool Paints - A durable, smooth surface created by painting with a rubber-base waterproof enamel paint will resist the intrusion of clinging algae.

V. POOL AND POOL AREA MAINTENANCE

A. CRACKS IN THE POOL

1. Loss of Water - The loss of water through cracks in the pool can amount to a considerable volume. A loss of 1 inch of water from a pool in an overnight period represents 625 gallons for each 1,000 square feet of pool surface area.

2. Repair - Special hydraulic cement compounds can be used to patch small to medium sized cracks. Tar and asphalt fillers should not be used as they are unsightly and will extrude into the pool.

3. Prevention of Cracks Caused by "Earth - Heave". - Many pools and especially those constructed by the "gunite" process will crack if drained for any length of time. It is desirable in these cases to leave water in the pool at all times. Plastic pool covers will prevent algae growth and debris accumulation during winter periods. These covers can be securely installed to prevent accidental drowning of children.

B. POOL CLEANING

1. Suction Cleaners - Suction cleaners installed as part of the system or maintained as a separate system, are a valuable adjunct to the pool maintenance program. Devices are

available which will operate off of a common garden hose. Daily use of these devices is a necessity.

2. Leaf and Bug Rake - A long handled wire net is useful in clearing the water surface each morning.

3. Magnet Collector - A magnet on a long stick is useful in removing metallic objects such as hairpins from the pool.

4. Pool Interior Surface Stains - A cleaning compound containing tri-sodium-phosphate is useful for daily cleaning of the overflow gutters and water level areas of the pool.

   A 5% solution of hydrochloric acid is useful in removing tenaceous calcium deposits from the pool structure.

C. POOL PAINTING

1. Purpose of Painting

   a. Reduce spalling - The freezing and expansion of water which soaks into the concrete can cause flaking off of layers of concrete.

   b. Reduce algae penetration and harborage for debris - A smooth surface is a desirable one.

   c. Reduce chemical attack - The objectional effect of water on the pool sides may be diminished by painting.

2. Types of Paint

   a. Oil base paints - These are rapidly destroyed both by the water and the concrete.

   b. Water-mixed cement paints - This material deteriorates and will not last long.

   c. Vinyl paints - These are difficult to apply and are subject to blistering and peeling.

   d. Rubber-base paints - These paints are probably the most suitable but difficulties may be expected in applying them over a previous layer of paint.

VI. OFF-SEASON PROTECTION

A. RECIRCULATION EQUIPMENT

1. Filters - These should be inspected and operational problems corrected before being thoroughly backwashed and completely drained.

2. Feeding Equipment and Make-Up Tank - All feeders should be thoroughly cleaned and completely drained. Light applications of petrolatum and clear oil might be indicated to prevent corrosion during storage.

3. Disinfection Equipment - All parts of this equipment should be completely drained and metal parts coated with petrolatum.

4. Pump - This should be drained, greased, and the fuses removed from the pump switch.

B. POOL PROPER

1. Ice Thrust - Wood poles may be placed along one side and one end as a protection against ice thrust pressure.

2. Pool Cover - A plastic pool cover will prevent accumulation of debris and algae growths.

C. POOL AREA

1. Deck Equipment - All deck equipment should be stored inside to prevent damage or vandalism. Springboards should be placed on a flat, dry surface to prevent warping.

2. Drinking Fountains - These should be drained and covered to prevent staining.

3. Lighting - Floodlight bulbs and reflectors should be removed and the sockets plugged. Reflectors may be coated with a clear oil to protect against rusting.

D. SERVICE BUILDINGS

1. Water Supply - The water supply should be cut off and all fixtures drained.

VI. OFF-SEASON PROTECTION

A. RECIRCULATION EQUIPMENT

1. Filters - These should be inspected and operational problems corrected before being thoroughly backwashed and completely drained.

2. Feeding Equipment and Make-Up Tank - All feeders should be thoroughly cleaned and completely drained. Light applications of petrolatum and clear oil might be indicated to prevent corrosion during storage.

3. Disinfection Equipment - All parts of this equipment should be completely drained and metal parts coated with petrolatum.

4. Pump - This should be drained, greased, and the fuses removed from the pump switch.

B. POOL PROPER

1. Ice Thrust - Wood poles may be placed along one side and one end as a protection against ice thrust pressure.

2. Pool Cover - A plastic pool cover will prevent accumulation of debris and algae growths.

C. POOL AREA

1. Deck Equipment - All deck equipment should be stored inside to prevent damage or vandalism. Springboards should be placed on a flat, dry surface to prevent warping.

2. Drinking Fountains - These should be drained and covered to prevent staining.

3. Lighting - Floodlight bulbs and reflectors should be removed and the sockets plugged. Reflectors may be coated with a clear oil to protect against rusting.

D. SERVICE BUILDINGS

1. Water Supply - The water supply should be cut off and all fixtures drained.

2. Electrical Service - The service main should be cut off and all fuses removed.

3. Suits and Towels - All of these articles should be packed in rodent and insect tight containers and protected against excessive moisture.

VI. SERVICE OPERATIONS AND MAINTENANCE

A. LOCKER FACILITIES - Care must be taken not to crowd clothes storage units too close together. Adequate ventilation between storage units is a must.

Baskets and lockers should be cleaned weekly and inspected regularly for insect infestation.

B. LIGHTING - The maintenance of 10-foot candles of light at a point 3 feet from the floor is important from the standpoint of safety as well as proper cleaning.

C. VENTILATION - The worth of a pool will be determined by what a patron sees or smells. Deodorants should not be used as a substitute for routine cleaning or good ventilation.

Damage to plumbing and metal structural members, wood rot, unsightly stains, and plaster deterioration are all results of poor ventilation.

D. MAINTENANCE OF SANITARY FACILITIES - Lavatories, urinals, and toilets should be cleaned and disinfected at least twice daily. Liquid soap, single use towels, and toilet tissue must be available at all times.

E. APPURTENCES

1. Furniture - Furniture including dressing booth should be kept as simple as possible. Twice a season painting will prolong the life of wooden articles.

2. Mirrors - The provision of disposable tissues near the mirrors in the women's dressing room will help prevent smearing of the walls with lipstick.

3. Waste Receptacles - Mail-box type receptacles are a must in all dressing rooms.

F. FLOOR CLEANING AND MAINTENANCE

1. Slippery Floor Conditions

a. Application of strong non-acid cleaning powders - Frequent applications will render smooth concrete or terrazzo surfaces non-slip.

b. Application of adhesive non-slip strips - Non-slip granular surfacing is available in self-adhering strips. The strips adhere firmly and yet do not prohibit satisfactory floor cleaning.

2. Floor Cleaning and Disinfection

a. Disinfection - The application of a 0.3 to 0.6% solution of hypochlorite is an acceptable method of floor disinfection.

b. Cleaning combined with disinfection

(1) Method 1 - A combined cleaner and disinfectant is used to mop the floor. One such product combines detergent with benzylated phenol.

(2) Method 2 - The floors are hosed down and then a lye (caustic) solution is applied with a stiff brush. The lye solution is made up by mixing one-half of a 13-ounce can of lye in a bucket of hot water.

G. ATHLETE'S FOOT CONTROL

1. General - This infectious fungus is frequently transmitted through bathhouse floors, mats, and floor coverings. Approximately 50% of our population is infected to some degree.

2. Personal Prevention

a. Foot covers - Patrons may wear their own clogs while using the bathhouse facilities.

b. Drying agents - Moisture is an important factor in the protection against this fungus infection. Medicated powders keep the feet dry while also applying preventive or curative chemicals.

3. Public Prevention

a. Wooden walkways and mats - These must be eliminated since they are extremely difficult to disinfect. Mats on springboard can be replaced with non-slip granular surfacing.

b. Foot treatment

(1) Foot baths - Foot baths that consist of a reservoir to be filled with a disinfectant solution should be replaced by fast flow through foot baths. The only function of the latter is to wash off debris from the feet before the patron enters the pool area.

(2) Foot tougheners - A salt soaked pad (10% NaCl) is used as a device for toughening the bottom of the feet to prevent fungus attack. The fungus cannot live in the strong salt media of the pad.

H. SUIT HANDLING AND DISINFECTION

1. Rented Suits

a. Handling - Used suits should not be returned at the same counter where fresh suits are delivered.

b. Treatment

(1) Heat treatment - The suits are washed in hot soap and water followed by rinsing, drying and ironing.

(2) Chemical treatment - The suits are soaked for 5 minutes in a 1,000 ppm solution of a quaternary ammonium compound such as alkyl-dimethyl-benzyl-ammonium chloride.

2. Owners Suits - While difficult to enforce, it has been recommended that patrons be instructed to use a two compartment sink in which personal suits might be disinfected as noted above and then rinsed and wrung out.

I. SWIMMER INSPECTION AND PERSONAL REGULATIONS

1. Cleansing Showers - The strict regulation of cleansing showers might be made much more acceptable if tempered water were provided for the patron. Adherence to this practice lightens the load on filtration and disinfection

equipment.

2. Exclusion of Diseased Patrons - A systematic effort should be made to inspect all patrons, and exclude those showing symptoms of any infectious condition.

3. Personal Regulations - A form containing a list of suggested personal regulations is included with this manual on page 110.

J. SAFETY

1. Life Saving Equipment

   a. Reaching poles - One or more light poles of no less than 12-foot length should be available for making reaching assists.

   b. Throwing buoys - Buoys, not more than 15 inches in diameter, having 60 feet of 3/16-inch manilla line attached should be placed on racks at strategic points adjacent to the pool.

2. First-Aid Equipment and Facilities

   a. First-aid equipment

      (1) First-aid kit - A standard 24-unit first-aid kit should be kept filled and readily accessible for emergency use.

      (2) Additional equipment - A stretcher and two woolen blankets should also be available.

   b. First-aid room - An area or room should be set aside for the emergency care of casualties.

   c. Telephone - Every swimming pool should have a telephone and provided near it, a list of emergency numbers, such as the nearest available doctor, ambulance service, hospital, and rescue squad.

K. OPERATIONAL RECORDS - The efficiency of any endeavor depends on the keeping of suitable records. A suggested record form for the pool manager and operator is included with this outline on page 111.

The following list of Swimming Pool Sanitary and Safety Requirements is prepared as a suggested placard form that might be posted at several points in the pool area.

NOTICE

_______________ PUBLIC HEALTH DEPARTMENT

SWIMMING POOL SANITARY AND SAFETY REQUIREMENTS

1. ALL PERSONS USING THE POOL MUST TAKE A CLEANSING SHOWER BATH IN THE NUDE, USING SOAP AND WATER, BEFORE ENTERING THE POOL.

2. ALL SWIMMERS LEAVING THE POOL TO USE THE TOILET MUST TAKE A SECOND CLEANSING SHOWER BEFORE RETURNING.

3. ALL SWIMMERS SHOULD USE THE TOILET AND PARTICULARLY EMPTY THE BLADDER BEFORE TAKING THEIR CLEANSING SHOWER AND ENTERING THE POOL.

4. ANY PERSON HAVING ANY APPARENT SKIN DISEASE, SORE OR INFLAMED EYES, COUGH, COLD, NASAL OR EAR DISCHARGE, OR WEARING BANDS OR BANDAGES, OR HAVING ANY COMMUNICABLE DISEASE SHALL BE EXCLUDED FROM THE POOL EXCEPT ON PRESENTATION OF A WRITTEN PERMIT OF CURRENT DATE SIGNED BY A PHYSICIAN.

5. SPITTING, SPOUTING WATER, AND BLOWING THE NOSE ARE PROHIBITED IN THE POOL. THE OVERFLOW GUTTER IS TO BE USED FOR EXPECTORATION.

6. NO BOISTEROUS OR ROUGH PLAY, EXCEPT SUPERVISED WATER SPORTS, IS PERMITTED IN THE POOL, ON RUNWAYS, ON DIVING BOARDS, FLOATS, PLATFORMS, OR IN THE DRESSING ROOMS AND SHOWER ROOMS.

____
Health Officer

The following pool operators record is prepared as a suggested form to be used in maintaining operational records at swimming pools.

____

POOL OPERATOR'S WEEKLY REPORT – WEEK BEGINNING__________ __________Swimming Pool

Type of Pool ______________________ Location ______________________

Number of Swimmers			Remarks	Daily Tests					
				pH	Chlorine or other disinfectant Residual (ppm)				Temperature of water (°F)
					Deep End		Shallow End –		
Day	Male	Female			AM	PM	AM	PM	
Sun.									
Mon.									
Tues.									
Wed.									
Thurs.									
Fri.									
Sat.									

Number of Hours Operation			Length of Time Each Filter Backwashed (min)	Volume of make up water Added (Gallons)	Pounds of Chemical Added			
Day	Filters	Disinfecting Equipment			Soda Ash or other pH Control Substance	Alum or Other Coagulant	Disinfectant	Algicide
Sun.								
Mon.								
Tues.								
Wed.								
Thurs.								
Fri.								
Sat.								

Signed ______________________

This report should be posted for inspection by the ______________________ ____Health Department

REFERENCES

American Public Health Association; Recommended Practice for Design, Equipment and Operation of Swimming Pools and Other Public Bathing Places; American Public Health Association; New York, New York; 1957.

Butterfield, C. T.; "Bactericidal Properties of Chloramines and Free Chlorine in Water"; Public Health Reports; Vol. 63; No. 29; July, 1948.

Cox, C. R.; Water Supply Control; New York State Department of Health; Albany, New York; 1952.

Meslin, J.; Swimming Pool Operator's Text; Florida Swimming Pool Operators' Association; Miami, Florida; 1957.

Pearce, R. W.; "Principles of Chlorine Gas Feeders"; Water and Sewage Works; Vol. 101; No. 10; 1954.

Perkins, R. N.; Operating Manual for Swimming Pools; Refinite Company; Ralston, Nebraska; 1946.

State of Illinois Department of Health; Swimming Pool Operation; State of Illinois; Springfield, Illinois; 1955.

Thomas, D. G.; Pool Filtration and Chemistry; Thomas Printing Company; Cleveland, Ohio, 1957.

Van Kleek, L. W.; "Operating and Maintaining Chlorinators and Chlorine Containers"; Wastes Engineering; Vol. 27; No. 7; July, 1956.

AUDIO-VISUAL AIDS

CDC Slide Set (S142)"Water, Sewage and Swimming Pool Graphics."

CDC Filmstrip (F133) - "Swimming Pool Sanitation."

CDC Filmstrip (F225) - "Operation of Hypochlorinators."

CDC Filmstrip (F146a) - "Functioning of Gas Feed Chlorinators, Part I."

CDC Filmstrip (F146b) - "Functioning of Gas Feed Chlorinators, Part II."

Filmstrip - "Pump Maintenance"; Allis-Chalmers Manufacturing Co.; Milwaukee, Wisconsin.

INSTRUCTION AIDS

1. Chemical samples

   a. Alum
   b. Diatomaceous Earth
   c. Soda Ash
   d. Calcium Hypochlorite
   e. Lime
   f. Copper Sulfate
   g. Sodium Bisulfate
   h. Muriatic Acid
   i. Tri-Sodium-Phosphate
   j. Sodium Sulfite
   k. Sodium Hexametaphosphate
   l. Calcium Hypochlorite
   m. Sodium Hydroxide

2. Samples of sand and anthrafilt filter media.

3. Diatomaceous earth filter septa.

   a. Tube
   b. Leaf

4. Swimming pool fittings

   a. Adjustable face, return water inlet
   b. Jet-Flo, return water inlet
   c. Main drain
   d. Vacuum connection
   e. Fill spout
   f. Skimmer
   g. Rate of flow indicator
   h. Alum pot
   i. Strainer
   j. Pool underwater light
   k. Sight glass
   l. Rate of flow controller

5. Section of overflow gutter

6. Environmental Health Training Section Posters

   a. Typical plan of pool service facilities

   b. Longitudinal section through pool showing fittings

   c. Swimming pool piping system

   d. Swimming pool equipment room

   e. The diatomite filter

   f. Liquids sampling report

   g. Swimming pool inspection report

   h. Pool operator's weekly report

   i. Flow diagram - Mechanical diaphragm, vacuum type chlorinator

   j. Flow diagram - Visible vacuum chlorinator

   k. Flow diagram - Solution feed chlorinator

7. Hypochlorinators

   a. Positive displacement pump

   b. Siphon feeder

   c. Dissolving basket

   d. Air controlled suction feeder

8. Sample of "granular-like" slip prevention strip

9. Samples of piping

   (a) steel
   (b) plastic
   (c) copper

10. Brominator

11. Small, laboratory type, centrifugal pump
12. Pressure gauge
13. Vacuum gauge
14. Garden hose fitted vacuum cleaner
15. Chlorine type gas mask and canister
16. Leaf and bug rake
17. Magnet type collecting stick
18. Pool thermometer
19. Chlorine or bromine residual and pH test kits
20. Concrete block painted with different types of pool paint

Lecture Outline

TESTING SWIMMING POOL WATER FOR CHLORINE RESIDUAL AND pH

I. CHLORINE RESIDUAL TESTING

A. GENERAL - Chlorine in common with other oxidizing agents, produces in acid solutions, a strongly colored yellow compound by reaction with ortho-tolidine. Small amounts of chlorine give a yellow, and larger amounts an orange color. The quantitative estimation is carried out by comparing this color with color standards representing definite amounts of free chlorine.

The proper development of color depends upon the sample having a low pH value. Pool waters which are extremely alkaline may produce green or blue hues instead of the typical yellow to orange. Such alkaline waters must be approximately neutralized with a small quantity of dilute hydrochloric acid before making the test.

Ortho-tolidine solutions should not be used after they are six months old, and must be stored in an amber bottle.

In chlorinated pool water containing no more than 0.3 ppm iron, 0.01 ppm manganic manganese and/or 0.10 ppm of nitrite nitrogen, the characteristic yellow color with ortho-tolidine may be accepted as being due to chlorine. The ortho-tolidine-arsenite test (see item I-C) should be employed if excessive amounts of these interfering substances are present or suspected of being present.

B. CHLORINE RESIDUAL "FLASH" TEST - (Range 0.0 to 1.0 ppm)

1. Equipment - The following procedure should be carefully followed when using the Hellige pocket comparator, Model 605. The procedure using other makes of comparators will be essentially the same.

2. Procedure

   a. Fill the two test tubes with 10 ml. of the water to be tested and place them in the comparator. The

Preceding page blank

tube in the left-hand opening of the comparator is the "compensation tube."

   b. Add with force 1.0 ml. (about 20 drops) of ortho-tolidine to the test tube in the right-hand opening.

   c. Quickly (within 10 seconds) match the colors by turning the disc until the color of the sample and that of the disc most nearly match. The reading is made directly in parts per million.

3. Compensation - The function of the second tube is that of optical or color compensation, insuring the comparison of similar media (liquid against liquid). In most cases difficulties due to color or turbidity in the original sample will thus be eliminated.

C. ORTHO-TOLIDINE-ARSENITE CHLORINE RESIDUAL TEST

1. Equipment - The equipment used is the same as noted above for the "Flash" test with the addition of sodium arsenite solution (5 gm. of sodium arsenite in 1 liter of distilled water).

2. Procedure

   a. Add 0.5 ml. of sodium arsenite solution to 10 ml. of test water in a test tube, mix and then add 0.5 ml. of ortho-tolidine.

   b. Compare with color standards against a "compensation tube" as above, and record result as false residual.

   c. Place 0.5 ml. of ortho-tolidine in a test tube and then add 10 ml. of test water.

   d. Immediately add 0.5 ml. of sodium arsenite solution.

   e. Compare with color standards against a "compensation tube" and record results as free chlorine plus false residual.

   f. The difference between readings found in steps b. and e. will yield the free chlorine residual.

D. FIELD TEST FOR CHLORINE RESIDUAL - DROP DILUTION METHOD (Range over 1.0 ppm)

1. Equipment - The equipment used is the same as above.

2. Procedure

   a. Place 0.5 ml. of ortho-tolidine into the test tube.

   b. Add 10 ml. of distilled water and mix thoroughly.

   c. Add one drop of test water to the tube and make a color comparison reading as before.

   d. If the addition of one drop of water produces no color, discard the contents of the tube and proceed as before, but add two drops of the water under test. Continue this procedure until an easily readable color is produced (not less than 0.1 ppm).

   e. Calculations of results are made by using the following formula:

$$\text{PPM Residual Chlorine} = \frac{\text{Volume of cell in ml.}}{\text{Ml. of Sample}} \times \text{Comparator Reading}$$

3. Example

$$20 \text{ ppm Residual} = \frac{10 \text{ ml.}}{0.05 \text{ (1 drop)}} \times 0.10$$

E. EMERGENCY TEST FOR COMBINED CHLORINE RESIDUAL IN DRINKING WATER (1.0 ppm)

1. Procedure

   a. Put 1/2 inch of chlorinated water into a cup and add 15 to 20 drops of ortho-tolidine.

   b. Let the solution stand for 5 minutes out of the sunlight and then note color.

2. Interpretation

   a. No color -- No chlorine

   b. Canary yellow -- About 0.5 ppm

   c. Deep yellow -- About 1.0 ppm

   d. Orange red -- More chlorine than necessary

   e. Bluish green -- Alkaline or hard water - Adding twice as much ortho-tolidine may provide the desired color development.

II. pH TESTING

A. GENERAL - Hydrogen ion concentration, or pH as it is commonly called, is an important measurement in swimming pool sanitation. Optimum coagulation, disinfection and summer comfort depend upon maintenance of a proper pH level.

pH is a quantitative measure of acidity or alkalinity, expressed in terms of hydrogen ion only, 7 being the neutral point and 14 being the complete absence of hydrogen ions and the presence of only hydroxyl ions. The opposite end of the pH scale approaches "0" with strong mineral acids prevailing giving a pH range of 0 to 14.

Colorimetric determination of pH is based on the ability of certain organic materials called indicators to change color in varying hydrogen ion concentrations. Addition of a small quantity of the indicator to the sample and comparison with a color standard permits rapid determinations of pH to be made.

B. pH TEST - COLOR COMPARATOR KIT

1. Equipment - The following procedure should be carefully followed when using the Hellige pocket comparator Model 605. The procedure using other makes of comparators will essentially be the same.

2. Procedure

   a. Fill the two test tubes with 10 ml. of the water to be tested and place them in the comparator. The tube in the left-hand opening of the comparator is the "compensation tube."

b. Add 0.5 ml. (about 10 drops) of indicator to the test tube in the right-hand opening.

c. Match the colors by turning the disc until the color of the sample and that of the disc most nearly match. The reading is made directly in pH units.

3. Compensation - The function of the second tube is that of optical or color compensation, insuring the comparison of similar media (liquid against liquid). In most cases difficulties due to color or turbidity in the original sample will thus be eliminated.

4. Indicator - Methyl red indicator measures a pH range of 6.8 to 8.4 and is probably the most useful one for use with swimming pool water.

C. EMERGENCY pH TEST - VISUAL COLOR DEVELOPMENT

1. Equipment - A clean test tube that will hold at least 10 ml. of water and a bottle of fresh brom thymol blue indicator solution are needed.

2. Procedure

a. Add the contents of a small medicine dropper of indicator to the test tube.

b. Add 10 ml. of test water and compare with the following standards:

Dark blue - about 7.6 (alkaline)
Pure light blue - about 7.0 (neutral)
Green - about 6.8 (acid)
Greenish yellow - about 6.4 (acid)
Yellow - about 6.0 (acid)

REFERENCES

American Public Health Association; Standard Methods for the Examination of Water, Sewage and Industrial Wastes; Tenth Edition; American Public Health Association; New York, New York; 1955.

Illinois State Department of Health; Swimming Pool Operation; State of Illinois; Springfield, Illinois; 1955.

War Department; Military Water Supply and Purification; United States Government Printing Office; Washington, D. C.; 1945.

Lecture Outline

INSPECTION OF POOL INSTALLATIONS AND BACTERIOLOGICAL SAMPLING OF PUBLIC SWIMMING POOL WATERS

I. SWIMMING POOL INSPECTIONS

A. GENERAL - The routine inspection of swimming pools is basically an inventory of operation and maintenance procedures carried out at the pool. It is not the purpose of this type of inspection to evaluate the soundness of original or remodeled construction. The detection of structural and equipment defects which exist because of poor operation and maintenance are, however, important goals of this type of visit. Structural changes necessitated by changes in normal pool load or operational character are also matters of concern in the routine inspection.

B. INSPECTION POLICIES

1. Frequency of Inspection - A minimum frequency of one visit each three weeks during the swimming season is essential for outdoor pools.

   Indoor pools which are used the year round and which do not have the heavy loading problem of the outdoor pools, might be inspected as seldom as once every two months.

   Any of the above minimum times are suggested for the average pool and less frequent or more frequent inspection might be in order for the unusual pool.

2. Time of Inspection - Inspections at times of minimum use and maximum use are as valuable in this field as they are in other fields of environmental sanitation, (*i. e.*, restaurant inspection).

   Operational problems such as difficulty in maintaining disinfectant residuals will necessitate review during maximum loadings, while problems of backwashing procedure might be facilitated by off-hour inspection.

3. Inspection Routine - As with any sanitary inspection, the best route of travel cannot be delineated because of the many variables involved. In general, however, the most efficient technique is one that will permit a thorough

inspection in the least possible time without excessive retracing of steps. One suggested technique is to review the service buildings first, proceed to the pool area and pool proper, and finish with an inspection of the equipment room or rooms.

The effectiveness of the inspection will be increased if the pool manager and/or equipment operator accompanies the person making the inspection as he tours the facilities.

C. MAKING THE INSPECTION - (See suggested "Swimming Pool Inspection Report", page 125)

1. Service Buildings - The person making the inspection will be concerned here with the details discussed in the "Operation and Maintenance" lecture outline as they pertain to dressing rooms, toilet and shower rooms, clothing storage, first aid and safety equipment, suit and towel handling, swimmer supervision, maintenance of records, and food service.

   Typical items would include the checking of shower heads for water temperature and flow, as well as the critical but constructive review of the clothing handling techniques.

2. Pool and Pool Area - In this field the problems of pool surroundings, spectator control, pool structure, pool fittings and appurtenances, and water quality will be of major importance.

   The testing of disinfection level and pH will be a routine procedure. See the lecture outline, "Testing of Swimming Pool Water for Chlorine Residual and pH," for complete details.

   Normally, other chemical tests of the pool water will not be run on a routine basis but "field kit testing" of such things as hardness and carbon dioxide content may be indicated. A field test kit for this purpose is described in reference number 5 of this outline.

   The testing of pool clarity is normally accomplished by visual inspection but the use of a 6-inch black disc painted on a white background may be used. This device on the end of a stout cord is thrown into the deep end of the pool

The following inspection report is prepared as a suggested form to be used in making routine swimming pool inspections.

____

NOTICE: This report shall not be defaced or removed except by the Public Health Director or his representative.

________________________________ HEALTH DEPARTMENT

SWIMMING POOL – INSPECTION REPORT

Name ____________________________ Type ____________________________

Address ____________________________

Sir: An inspection of your swimming pool has been made this day and you are directed to correct conditions marked (x).

A. Pool Structure:
  1. Floors, walls, runways ( )
  2. Scum gutters, skimmers ( )
  3. Ladders, stairs, stepholes ( )
  4. Diving boards, floats, depth ( )
  5. Inlets, outlets, circulation ( )
  6. Piping ( )
  7. Fencing ( )
  8. ____________________________ ( )

B. Supplemental Facilities
  1. Food service ( )
  2. Emergency equipment ( )
  3. ____________________________ ( )

C. Recirculation, Disinfection System
  1. Filtration, disinfection ( )
  2. ____________________________ ( )

D. Buildings, Galleries, Enclosures
  1. Walls, floors, ceilings, partitions ( )
  2. Lighting, heating, ventilation ( )
  3. Plumbing, drainage ( )
  4. Surroundings ( )
  5. Appurtenances ( )
  6. ____________________________ ( )

E. Water
  1. Disinfection level ________ ppm ( )
  2. Freedom from turbidity, debris, growths ( )
  3. pH ____________ ( )
  4. ____________________________ ( )

F. Showers, Toilets, Dressing Rooms
  1. Clean, adequate, accessible ( )
  2. Ventilation ( )
  3. Hot, cold water ( )
  4. Soap, towels ( )
  5. Disinfection ( )
  6. Lavatories ( )
  7. Clothing Storage ( )
  8. Refuse Containers ( )
  9. ____________________________ ( )

G. Records
  1. Number of bathers ( )
  2. Temperature – water ________ °F ( )
  3. Operational data ( )
  4. ____________________________ ( )

H. Bather Control
  1. Cleansing shower ( )
  2. Supervision ( )
  3. Communicable disease ( )
  4. Placards displayed ( )
  5. Common comb, towel ( )
  6. Rented suits and towels properly handled and cleaned ( )
  7. ____________________________ ( )

Date ______________

Sanitarian ____________________________

Remarks: ____

____

(Additional Remarks noted on reverse side) and observed from the pool edge.

The bacteriological sampling, normally done at this time is described below.

3. The Equipment Rooms - In this most important area, the filtration, recirculation and disinfection equipment and appurtenances will come under close scrutiny. Typical items of inspection will be the hair strainer, the chlorinator and the chemical feed devices.

   At least once during the swimming season, and preferably at the beginning, the filter surfaces should be inspected. Routine inspection of the filters should include a check of the air release valves, flow rate indicators, pressure gages, and condition of piping and tanks.

   Each inspection of this area must also include a review of all of the operational reports concerning the equipment. This often proves to be a most valuable tool in gaining an insight into the causes of operational problems.

4. Summary and Review of Findings - A detailed summary of the defect items should be made in the space provided under remarks on the inspection report. Reference should be made to the numerical items checked on the body of the report. In this way the responsible person may be instructed as to the details of the defect and may be advised as to how and when correction should be made.

   An office summary of the report can be made on a form similar to the one shown on page 127 of this brochure. It is also titled, "Swimming Pool Inspection Report." It gives the personnel of the health department a succinct summary of the pool's operational conditions over a considerable period of time.

   Another valuable office record is a tabulation of sampling results. A suggested office form titled, "Liquids Sampling Report," is included in this brochure on page 128 , for that purpose. With this form a record may be kept of the chlorine, pH, and bacteriological sampling results from a pool over an entire swimming season. This record form by itself serves as one good measure of a pool's operating efficiency.

The following record sheet is prepared as a suggested office form for the recording of defects found on inspection of swimming pools.

PUBLIC HEALTH DEPARTMENT
DIVISION OF SANITATION
SWIMMING POOL
INSPECTION REPORT

NAME______________________________
ADDRESS____________________________
TYPE______________________________
OPERATOR___________________________

DATE	A-CONSTRUCTION								B-SUPP-M'TAL FACIL'S			C SYS-TEM		D-BUILDING						E-WATER				F-DRESSING ROOMS									G-RECORDS				H-Swimmer Control							SANITARIAN
	1	2	3	4	5	6	7	8	1	2	3	1	2	1	2	3	4	5	6	1	2	3	4	1	2	3	4	5	6	7	8	9	1	2	3	4	1	2	3	4	5	6	7	

DHEW-ATLANTA, GA.

The following record sheet is prepared as a suggested office form for the recording of tests made on water, sampled from a swimming pool.

PUBLIC HEALTH DEPARTMENT
DIVISION OF SANITATION

LIQUIDS SAMPLING REPORT

NAME ____________________
ADDRESS ____________________
TYPE ____________________
OPERATOR ____________________

Date	Type of Product	No. 10 c.c. Tubes Positive *E. coli* or Coliform per 100 ml.	Bacteria Plate Count Per c.c.	pH	Chlorine Residual (ppm)	Sanitarian

DHEW-ATLANTA, GA.

II. BACTERIOLOGICAL SAMPLING OF POOL WATERS

A. PREPARATION OF SAMPLE BOTTLES

1. General - All sample bottles must be sterilized and treated with sodium thiosulfate to reduce the chlorine present in the water at the moment the sample is collected. If sodium thiosulfate were not used, the chlorine would be acting on the bacteria in the sample while it was being held or transported for testing.

2. Techniques of Preparation

    a. Moist heat sterilization - One-half ml. of sodium thiosulfate solution (1.5 gm. of sodium thiosulfate in 100 ml. of distilled water) is placed in a clean bottle (approximately 4 oz. size). The bottle is stoppered and capped, and then placed in an autoclave and sterilized for 30 minutes at a temperature of 121°C (250°F). In the event that a prepared solution of sodium thiosulfate is not immediately available, an approximate amount of powdered sodium thiosulfate in the range of 0.02 to 0.05 gm. may be added to the bottle before autoclaving. An estimated amount on the tip of a spatula is sufficiently accurate for this purpose.

    b. Dry heat sterilization - The correct amount of powdered sodium thiosulfate is added to a clean bottle and it is then stoppered and capped. An oven can then be used to treat the bottles for 10 minutes at 180°C (356°F). The temperature of sterilization must not approach 220°C (428°F) as sodium thiosulfate decomposes at this temperature.

B. COLLECTION OF SAMPLES

1. Time of Collection - Samples should generally be collected only when the pool is in use and preferably during periods of heaviest swimmer load. The hour of the day and day of the week should be varied in order to obtain, over a period of time, a representative cross section of the sanitary quality of the pool.

2. Place of Collection - It has often been suggested that the pool be sampled at the shallow end to obtain water of the poorest quality in the pool. This is not necessarily true. The sampling point should be varied over a period of time for the reasons given above.

   Composite samples may be taken if the pool is infrequently sampled but the dangers of sampler-contamination is greater with this technique.

   It is not necessary or desirable to have a swimmer collect a sample from the middle of the pool to avoid collection of heavily chlorinated return water. This problem may be avoided by collecting samples at points between return water inlets.

3. Technique of Sampling - The first step in sampling is to carefully remove the cap and stopper from the bottle without touching the inner surfaces of the stopper. The open bottle is then plunged beneath the water surface and swept forward until full. The stopper and cap are then replaced. The bottle must not be rinsed in the pool or the sodium thiosulfate will be removed.

C. DISPOSITION OF SAMPLES - The samples should be stored at a temperature of from 0°C to 10°C (32°F to 50°F) until delivered to the laboratory for analysis unless an immediate analysis is run on the spot. If it is not convenient to refrigerate the samples, it is desirable to deliver them to the laboratory within a short period of time. Pertinent data such as sampling time, location of sample, sampler's identification, and desired analysis should accompany the sample.

III. BACTERIOLOGICAL ANALYSIS OF POOL WATERS

A. TESTS FOR BACTERIOLOGICAL QUALITY OF WATER

1. Presence of Pathogens Themselves - This is a difficult process at best and for routine analysis would not give the degree of delicacy required.

2. Presence of Lactose-Fermenting, Spore-Bearing Anaerobic Bacilli - This test has favor with British bacteriologists but is not commonly used as a routine test in this country. It is used to indicate evidence of

a history of past pollution in the water.

3. Presence of Fecal Streptococci - This test is not commonly used. It does give evidence of recent pollution with fecal material.

4. Total Numbers of Bacteria by the Standard Agar Plate Count - This is a valuable measure of the quality of pool water and when used with the coliform test gives valuable complementary information on the organism load.

5. Presence of the Coliform Group of Organisms - The coliform organisms which in themselves are principally of a harmless type are present in large numbers in the intestinal tract of man and other warm-blooded animals. The normal feces of man contain 100,000 to 1,000,000,000 coliform organisms per gram.

B. MAJOR TYPES OF COLIFORM ORGANISMS (33 separate species and varieties in all, as noted in 1952)

1. Escherichia coli- This is the fecal type, and the most important in terms of pool water quality.

2. Aerobacter aerogenes - This is the soil or grain type, and is not necessarily associated with pathogens of man.

C. REASONS FOR CHOICE OF THE COLIFORM GROUP AS THE STANDARD TEST OF WATER QUALITY

1. Absence of a Simple Test for Pathogens - There is no practicable routine test for specific pathogens.

2. Relation to Pathogens - All enteric infectious agents disseminated through pool water find their way into water through sewage.

3. Mass of Numbers - As pointed out previously, fresh sewage always contains large numbers of coliform organisms.

4. Test Delicacy - Coliform organisms are easily tested for, and the test is extremely delicate. No appreciable quantity of fresh, fecal material can be present in a water and escape detection when the coliform test is properly carried out.

If we assume 300 billion *E. coli* are contributed by one individual (100 gallons of sewage) in a day, the presence of one person's sewage could easily be detected in 4,000,000,000 gallons of water. This is a volume of water equal to that used by a city of 88,000 people in one year.

5. Death Rate of Coliforms and Pathogens - The enteric bacterial pathogens are known to be equally as sensitive to environmental conditions outside the intestinal tract as are *E. coli*. If intestinal *E. coli* have gained entrance into a water and have disappeared therefrom, we are reasonably certain that pathogenic bacteria gaining entrance through the same channel have also disappeared.

D. DEFINITION OF THE ORGANISMS OF THE COLIFORM GROUP - These organisms are aerobic and facultative anaerobic gram-negative, non-spore-forming bacilli (rods) which ferment lactose with the production of acid and gas.

E. METHODS OF CONDUCTING THE COLIFORM EXAMINATION

1. Liquid and Solid Media by Standard Technique

   a. Presumptive test - Initial inoculation is 10 ml. of pool water into each of five lactose broth fermentation tubes. These are incubated for 24 ± 2 hours at 35° C ± 0.5°.

   b. Confirmed test - Positive lactose broth tubes (presence of entrapped gas) are carried over into brilliant-green lactose bile broth fermentation tubes or solid plates (Endo or EMB). The former are incubated for 48 ± 3 hours and the latter for 24 ± 2 hours at 35° C ± 0.5°. Negative or doubtful presumptive tubes are incubated for an additional 24 hours (or a total of 48 ± 3 hours) and carried through the confirmed test if indicated at the end of that time.

   c. Completed test - Positive brilliant-green bile tubes (entrapped gas) or plates (typical colonies) are carried over to an agar slant to be incubated for 24 to 48 ± 3 hours and into another lactose broth fermentation tube for 48 ± 3 hours at 35° C ± 0.5°. If gas is produced in the lactose broth tube the test is carried on by making a gram stain from the corresponding agar slant. If the stain is Gram-negative bacilli without spores, the test is positive (completed) for coliform; but if spores are present with a gram negative stain, the test must be carried further. This involves inoculation into a formate ricinoleate broth fermentation tube for 48 ± 3 hours at 35° C ± 0.5°, and if gas is produced, rerunning the completed test. The lack of gas production indicates a negative test.

2. The Membrane Filter Technique

   a. Method - A sample of water is pulled through a sterile pad of polymeric material such as cellulose by a vacuum of 20-30 inches of mercury at the rate of 1,000 - 1,200 ml. per minute. The bacteria present in the sample are deposited in the first 10 microns of the 150 micron thick pad.

      The membrane pad is then placed on a sterile absorbent pad which is saturated with M-Endo Broth MF (or M-Coliform Broth) and incubated at 35°C in an atmosphere of high humidity, for 16 to 18 hours. At the end of this time the coliform colonies which are red or pink and have a metalic surface sheen are counted. Most other organisms have been eliminated by the use of the coliform selective medium. The number of colonies counted on the filter divided by the ml. of pool water used gives the number of coliform organisms per ml.

   b. Advantages of the membrane filter technique

      (1) Speed - Only about 18 hours are required for a determination as compared to 48 to 72 hours by the liquid and solid media technique.

      (2) Quantity of water used - Large quantities of water may be used in this method.

      (3) Interpretations - An actual count of colonies instead of a statistical approximation is permitted by this method.

      (4) Records - The membrane may be saved permanently

by wetting the filter with 10% glycerol solution and drying at 100° C for 5 minutes.

c. Disadvantages of the membrane filter technique

(1) Laboratory skill - The skill required in mixing media and conducting the test is much greater than the standard technique.

(2) Limitations of test water - Water with large quantities of colloidal and suspended solids, or waters with high non-coliform bacterial populations that grow on Endo type broth, or waters with as much as 1 mg. per liter of zinc or copper may result in poor test results.

F. METHOD OF CONDUCTING THE STANDARD PLATE COUNT EXAMINATION - One ml., 0.1 ml. or other appropriate volume of the pool water is placed in a petri dish. Not less than 10 ml. of liquefied tryptone glucose extract agar at a temperature of 43° to 45° C is added to the water in the dish and then allowed to cool. The dish is incubated at 35° C ± 0.5° for 24 ± 2 hours. The number of colonies are then read.

G. INTERPRETATION OF TEST RESULTS

1. Coliform Test

a. Liquid and solid media test (generally carried only through the confirmed stage) - Not more than 15% of the samples over considerable length of time, such as a summer swimming season, should show positive results in any of the five 10 ml. test portions.

b. Membrane filter test

(1) General - Since a standard for swimming pools has not yet been developed for this type of test, the following tentative standard for drinking water is presented.

(2) Tentative standards

(a) The arithmetic mean density of all standard samples examined per month by membrane filter procedure shall not exceed one coliform per 100 ml.

(b) An occasional sample may have:

(1) 3 coliforms on a 50 ml. sample; or,

(2) 4 coliforms on a 100 ml. sample; or,

(3) 7 coliforms on a 200 ml. sample; or,

(4) 13 coliforms on a 500 ml. sample; or,

(5) 22 coliforms on a 1,000 ml. sample;

Provided it does not occur in --

(I) consecutive samples; or,

(II) more than five per cent of samples when 20 or more samples per month are examined; or,

(III) more than one sample when less than 20 samples per month are examined.

2. Standard Plate Count - Not more than 15% of the plates over a considerable length of time should show more than 200 bacterial colonies per ml.

H. REASONS FOR BACTERIAL LIMIT VIOLATIONS

1. Pool Area and Equipment

a. Structure of pool - The lack of a smooth inner pool surface contributes to the harborage of foreign matter and micro-organism growths.

b. Disinfection - Inadequate disinfection devices, pool algae control and easy access of foreign matter such as leaves, and other organic matter will soon result in poor bacteriological reports.

c. Water treatment equipment - Filtration equipment which is incapable of proper quality of filtration or of handling a proper quantity of water is a prime cause of poor water condition.

2. Swimmer Control - The simple matter of overlooking the requirement of cleansing showers for swimmers could result in poor bacteriological reports.

3. Make-Up Water - Poor quality make-up water added to the pool will obviously result in the contamination of otherwise satisfactory water.

4. Sampling Procedure - Deviation from recommended sampling procedures could result in false results.

REFERENCES

American Public Health Association; Recommended Practice for Design, Equipment and Operation of Swimming Pools and Other Public Bathing Places; American Public Health Association; New York, New York; 1957.

American Public Health Association; Standard Methods for the Examination of Water, Sewage and Industrial Wastes; Tenth Edition; American Public Health Association; New York, New York; 1955.

Clark, H. F.; "Advantages and Limitations of the Membrane Filter Procedure"; Water and Sewage Works; September, 1957.

Gainey, P. L. and Lord, T. H.; Microbiology of Water and Sewage; Prentice-Hall; New York, New York; 1952.

Training Branch; Laboratory Manual for Water and Sewage; Communicable Disease Center; Public Health Service; Atlanta, Georgia; 1958.

Microbiology, Water Supply and Water Pollution Control Section; "Technical Recommendation contained in Personal Communication"; Robert A. Taft, Sanitary Engineering Center; Cincinnati, Ohio.

AUDIO-VISUAL AIDS

1. CDC Filmstrip (F5140) - "Sampling and Testing Drinking Water"

INSTRUCTION AID EQUIPMENT

1. Agar slants
2. Alcohol burner
3. Bacteriology instruction placard - EHTS
4. Brilliant green bile broth fermentation tubes
5. EMB agar plates
6. Endo agar plates
7. Field test kit - water and sewage - EHTS
8. Formate ricinoleate broth fermentation tubes

9. Gram stain slides
10. Inoculation needle
11. Inspection report placard - EHTS
12. Lactose broth fermentation tubes
13. Liquid sampling report placard - EHTS
14. Millipore (or equal) sanitarian's bacteriological sampling kit and mailing box complete with filters and media
15. Office record - inspection report placard - EHTS
16. pH and chlorine residual color comparator
17. Pool visibility disc
18. Sabro (or equal) membrane filter field test kit complete with coliform incubation boxes and media
19. Sample of sodium thiosulfate crystals
20. Swimming pool water sample bottle

Note: EHTS refers to the Environmental Health Training Section of the Training Branch, Communicable Disease Center.

This list is presented as a means of rating a pool in terms of some important maintenance and operation items.

OPERATION CHECK LIST FOR SWIMMING POOLS

How many of these can be answered YES at the pool? Grade two points for each NO and subtract the total from 100. Omit all questions that do not apply.

1. Can it be said that no disease has been transmitted at the pool in the past year?

2. Can it be said that no accident has occurred at the pool in the past year?

3. Do you have an adequate first-aid kit?

4. Is a telephone (with doctors' emergency-call numbers posted near it) available?

5. Do you have rescue equipment and a first-aid room?

6. Are periodic checks made to find dangerous practices or conditions, which checks are in turn followed by proper action if necessary?

7. Are water depths clearly marked and visible at night?

8. Are there adequate, well-trained, tactful, and conscientious personnel for all necessary duties?

9. Are premises clean and attractive?

10. Are bathhouse floors and fixtures cleaned and disinfected regularly?

11. Are "Personal Regulations" posted and enforced?

12. Are sufficient toilets and showers provided?

13. Are drinking fountains of the approved type?

14. Is each swimmer required to take a nude shower, with soap, before entering the pool?

15. Is there an adequate supply of premixed, tempered water?

16. Is liquid soap provided?

17. Are towels laundered after each use, and properly stored and handled?

18. Have the service building floor-wall joints been coved for easy cleaning?

19. Has the foot bath been eliminated or converted to the flowing-through type?

20. Is the hair and lint strainer cleaned at least twice weekly?

21. Have all cross-connections been eliminated?

22. If a gas chlorinator is used, is it housed in a separate enclosure?

23. Is an approved disinfecting-agent residual maintained in the pool water at all times?

24. Are adequate and accurate residual disinfectant and pH test kits provided?

25. Are frequent tests made for residual disinfectant and pH?

26. Do all enclosures have proper ventilation?

27. Is a proper dosage of alum applied to filter influent following each sand filter washing (or diatomaceous earth in the case of that type of filter)?

28. Is the pH maintained above 7.0?

29. Is the chemical-dosing equipment in proper operating condition?

30. Have the filter interiors and media surface been inspected in the past year?

31. Are the filters being properly washed when necessary?

32. Is the volume of water in the pool known and posted?

33. Is the pool water constantly maintained at overflow level?

34. Are the floors and pool walks properly drained, easily cleaned, and surfaces smooth, yet non-slip to wet feet?

35. Is the suction cleaner in good operating order?

36. Is the pool water crystal clear and free from algae?

37. Is dirt promptly removed from the pool bottom?

38. Is the water temperature maintained in the range of 76 degrees to 78 degrees F. (indoor pools)?

39. Are persons in street clothing prevented from walking on the pool walks?

40. Are daily operation records kept?

41. Are proper off-season protection measures taken?

42. Has the wading pool been converted to a spray or fast-flow-through pool?

43. Are all dirt, sand, and grassy areas eliminated from the pool area?

44. Have woodwork and treatment equipment been painted in the past two years?

45. Have the last ten bacteriological analyses of pool water been reported: "Water safe for swimming"?

46. Does the operator know the swimmer capacity of the pool?

47. Does the pool have an "approved" rating from the Department of Public Health?

48. Does the pool operator have adequate textbook references on pool operation and water treatment?

49. Has the pool operator attended an operator's course within the last two years?

50. Is everything possible being done to provide safe, clean, and enjoyable swimming facilities?

Adapted from: "Swimming Pool Operation"
State of Illinois Department
of Public Health

INDEX

Page

Accidents 5, 101, 139
Adhesive Strips 107
Air Relief Valve 36, 39, 78, 97, 126
Algae 84, 101, 104, 135, 141
Alum Pot See Coagulant Feeders
Anthrafilt Filters 35, 78, 97
APHA Technique (Swimmer Load) 23, 59
Athlete's Foot 107

Backwashing 20, 35, 39, 78, 94, 95, 97, 99, 123
Backsiphonage Protection 24, 40, 74, 78, 140
Bacteria
  Effect of Algae 101, 135
  Sampling Containers 129
  Sampling Procedure 129, 136
  Standards 81, 134, 135, 141
  Testing 130
Bathhouse
  Construction 15, 51, 71, 140
  Maintenance 106, 110, 139
Bathing Load See Swimmer Load
Bromine 48, 83

Calcium Hypochlorite See Hypochlorite
Carbon Dioxide 124
Chlorine - Ammonia 48, 83
Chlorine Gas
  Equipment Design 15, 41, 77, 140
  Equipment Maintenance 6, 90, 105, 126
  Equipment Operation 77, 90
  Leaks 90
  Masks 92
Chlorine Reduction 101, 103
Chlorine Residual 83, 84, 102, 140
Chlorine Residual Testing 117, 124, 140
Coagulants 33, 84, 85, 93, 140
Coagulant Feeders 20, 33, 64, 78, 93, 105
Coliform 131, 132, 133, 134, 135
Cooling 50
Copper Sulphate 102, 103
Corrosion 86

INDEX

Page

Covers for Pools 103, 105
Cross-Connections See Backsiphonage Protection

Depths 25, 30, 74, 75, 139
Diatomaceous Earth
    Filter Aid 20, 36
    Filter Design 32, 68, 77, 78
    Filter Maintenance 99, 105, 126, 140
    Filter Operation 36, 95, 99
    Feeders 34, 78, 95
Diseases 5, 109, 110, 139
Disinfectants See individual types of disinfectants
Diving Boards 6, 30, 74, 110
Drinking Fountains 30, 74, 105, 139

Earth-heave 103
Educational Program 1, 11, 141
Effective Size 35

Fencing 30, 73
Fill Spout 18, 20
Filters See individual types of filters
First Aid 93, 109, 139
Floors
    Construction 51, 52, 53, 71, 72, 77
    Cleaning 107, 139
Food Service 54, 73, 124
Foot Baths 108, 140
Fresh Water Supply 23, 40, 74, 85, 105, 136

Gunite 24

Hair Strainer 18, 33, 78, 86, 126, 140
Hardness 95, 99, 102, 120, 124
Headroom 30, 74
Heating
    Air 52, 72
    Water 20, 49, 53, 72, 79, 100, 124, 140, 141
Hose Bibs 27, 52, 72, 73
Hydrochloric Acid 85, 89, 100, 104, 117
Hydrogen Ion Concentration See pH
Hydrogen Sulfide 102

INDEX

Page

- Hypochlorite
  - Equipment 47
  - Equipment Maintenance 89, 105, 126
  - Special Uses 98, 103, 107
  - Stock Solutions 88, 89

- Inlets 18, 26, 66, 75
- Inspection of Pools 10, 123, 141
- Iodine 49

- Leaf and Bug Rake 104
- Lifeguard 31, 73
- Lighting 27, 51, 52, 72, 74, 77, 105, 106
- Lime 33, 85
- Lockers and Bags 52, 106
- Loss of Head Gauge 40
- Lye (Sodium Hydroxide) . . . . See Sodium Hydroxide

- Magnet Collector 104
- Main Drain Outlets 18, 26, 66, 75, 76
- Make-up Tank 18, 20, 40, 79, 86, 105
- Make-up Water 23, 40, 74, 85, 105, 136
- Manhole (filter) 36, 39
- Membrane Filter 133
- Mirrors 106
- Motel Pools 22
- Mudballs 98
- Muriatic Acid 85, 89, 100, 104, 117

- Odor 101
- Off-Season Protection 105, 141
- Orthotolidine 117, 118, 119
- Outlets . . . . See Main Drain Outlets
- Overflow Gutter 18, 28, 41, 76, 110
- Ozone 49

- Painting 103, 104
- pH
  - Control Equipment 33, 65, 78, 95, 105, 126
  - Definition 120
  - Factors affecting 84, 101
  - Limits 23, 84

INDEX

Page

pH (continued)
  Testing 120, 124, 140
Plans
  Review 6, 61, 71
  Submission 7, 8
Pool Structure
  Construction 24
  Maintenance 103, 124, 141
  Shape 15, 75
  Slope 15, 75
  Surfacing 24, 75, 135
Pool Types 11
Poured Pools 24
Prefabricated Pools 24
Pressure Gauges 35, 39, 78, 97, 126
Pumps and Motors. 18, 32, 63, 77, 86, 105

Quaternary Ammonium Compounds 102, 108

Rate of Flow Controllers 36, 39, 40, 78, 97
Rate of Flow Indicators 36, 39, 78, 126
Recirculated Water Inlets . . . . See Inlets
Records 109, 111, 124, 126, 127, 128, 141
Runways 25, 73, 110

Safety. 81, 93, 101, 109
Sand Filters
  Design 32, 35, 39, 61, 68, 69, 70, 77, 78
  Maintenance 97, 105, 126, 140
  Operation. 35, 39, 93, 96
Scum Gutters . . . . See Overflow Gutters
Showers 53, 72, 108, 110, 124, 136, 139
Sight Glass 36, 78
Silver. 49
Soda Ash 33, 85, 95
Sodium Arsenite 117, 118
Sodium Bisulfate 85, 98
Sodium Hexametaphosphate 89, 99, 100
Sodium Hydroxide (Lye) 85, 95, 98, 107
Sodium Hypochlorite . . . . See Hypochlorite
Sodium Thiosulfate 103, 129

INDEX

Page

Spectators 15, 30, 74, 124, 141
Spray (Wading) Pools 31, 76, 141
Steps and Ladders 29, 74
Suits and Towels 106, 108, 124, 140
Sulfuric Acid 85
Sunbathing 25
Superchlorination 103
Surface Skimmers 18, 28, 76
Surroundings of Pool 29, 73, 124
Swimmer Load
    Design Limit 22, 59, 141
    Operation Limit. 13, 81, 129

Toilet Facilities 53, 72, 73, 106, 110, 124, 139
Tri-Sodium Phosphate 104
Turbidity 23, 85, 95, 101, 124
Turnover 31, 35, 77

Ultra-Violet Light 49
Uniformity Coefficient 35

Vacuum Cleaning 18, 20, 32, 75, 103, 141
Vacuum Gauges 99
Ventilation 46, 50, 52, 72, 77, 90, 92, 106, 140

Wading (Spray) Pools .... See Spray Pools
Wash Water Tank 40
Waste Receptacles 72, 74, 106
Waste Water 26, 74, 78
Water Loss 103
Water Quality .... See individual measurements

* U.S. GOVERNMENT PRINTING OFFICE 1959 O—501047